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MAN AND NATURE

(A SYMPOSIUM OF MODERN KNOWLEDGE)

BY

EMINENT SCIENTISTS

(Frazer, Tylor, Haldane, Baker, Huxley & Levy)

WITH AN INTRODUCTION

BY

M. N. ROY

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INTRODUCTION

THE EVOLUTION OF HUMAN SOCIETY

BY M. N. ROY

THE subject has more than one aspect. It can be studied from different points of view. There is the process of past development. We may also try to find out the broad outlines of future progress. But the problems are interrelated. The future of human society cannot be visualised and planned, unless there is an understanding of the causes of its evolution.

The first question that rises in our mind when we try to discover the cause of the evolution of human society is, whether the law governing the process is teleological or deterministic. In other words, whether there is an extraneous purpose causing the process, or the law of social evolution is inherent in the process itself. On the other hand, one may even wonder if there is any law at all. To the superficial observer, it appears all so very chaotic and arbitrary.

It is generally agreed that human being is a social animal. By some compelling instinct, he

likes to live in a community. But what is the nature of that instinct? How does that instinct itself come about? On this question, there is no agreement.

The description of the development of human society is contained in the history of the world. But until recently, history itself was a very unreliable guide. It was written largely as a legend. Most books on history are written that way even to-day. Generally, history is written and studied as a mere chronicle of events. Past history was seldom written when the events occurred, but very often *post factum*. Consequently, it was bound to be coloured by the subjective predilections of the chronicler. That is certainly not a reliable guide for any scientific investigation.

Only very recently, a new approach to the study of history has been found. According to that, history must be regarded as a science. As a science, history itself must also have certain underlying laws. At this point, we are confronted with a new problem. Some of the leading scientists of to-day are of the opinion that strict determinism can no longer be found even in physical nature. They are inclined to hold that some sort of a mystic force can be detected as the background of all physical events. In the case of history, the desire to attribute the motive of all developments to some teleological cause is much more widespread. It is argued that history may be studied

as a branch of social science. But human society is composed of living entities. The investigation into the origin and the evolution of human society cannot be analogous to the study of a conglomeration of inert obejects. It is simply absurd to maintain that the behaviour of living entities could be governed by any deterministic laws, not to be traced to some super-human or super-natural source. In other words, it is maintained that the evolution of human society is a purposeful process, the object being unfoldment of the divine or metaphysical or spiritual force latent in every human being.

This assertion cannot be simply pushed aside. It can be challenged with very weighty arguments; but equally weighty arguments could be advanced from the other side. We are dealing with a hypothesis: The evolution of human society, including the march of history, ceases to be a chaotic process if we assume for its cause something which is also living, intelligent, purposeful. Strictly speaking, it is rather a postulate than a hypothesis. The object of the study is a process which vanishes into the infinity, and the process involves an endless number of living entities. The difficult study of a complex subject is simplified by the hypothesis.

But no hypothesis is scientifically valid unless it can be verified. In order to test the validity of the assumption of a purpose underlying the

process of human evolution, it is necessary to go beyond the limits of human society; it is necessary to penetrate far into the realm of biological evolution.

Human society is a community of living things called human beings. The laws of social evolution could be regarded as distinct from the laws of biological evolution only on the assumption that human beings are essentially different from the so-called lower animals. It is assumed that human beings have always been there, and have been always as they are to-day. Biology does not permit this assumption. It is definitely known that human beings have not always been as they are to-day, and that at a certain stage of organic evolution human existence merges into animal existence. The life is there; even to some extent mental faculties can also be traced in an embryonic form. Those living, intelligent organisms are not human beings. The Darwinian theory of the descent of man is still disputed by many. The theoretical objections raised from that quarter, however, are again based on unverifiable hypotheses. In any case, from the scientific point of view, those objections are not very serious. Whatever may be the doubt regarding the descent of man, however much may be made of the so-called missing link, no scientifically educated man to-day would assert that the human being is a special creation of God. The

only valid objection was the problem of the missing link. That problem has been solved to a very large extent by recent discoveries; moreover, theoretically, it has completely ceased to be a problem. The observed fact of mutation definitely disposes of the last scientific objection. So, the generally accepted conclusion, valid for all scientific study, is that human existence is the most developed stage of organic evolution.

Let us examine the hypothesis in the light of its own merit. If the evolution of human society were purposeful, then it should be possible to trace that purpose all the way through the process of organic evolution. Scientists with teleological prejudices have come to realise that their case is weakened by maintaining that the purposiveness is limited only to human existence. Therefore, efforts have been made to trace it also in the lower animals. Undoubtedly, wherever there is intelligence, there is some purpose, and intelligence appears at a certain stage of the evolution of life. Therefore, it is but natural that the purposiveness does not originate with human beings, but could be traced also in less developed biological forms. But that does not prove that the purpose itself is not a part of the physical structure of the organism. It is not proved that the purpose is something extraneous to the process of biological evolution.

As a matter of fact, the discoveries of modern chemistry, biology and allied sciences offer enough evidence for the rejection of the doctrine of a teleological purpose. It is no longer necessary to regard life as the manifestation of some immaterial force. All the other manifestations which culminate in the human being as his spiritual properties, can be traced ultimately to the vital phenomenon, and this in its turn can be traced to the physical substratum of the entire organic existence. These evidences of modern science compel the rejection of the doctrine that the evolution of human society is guided by some instincts which are peculiar to human beings, and consequently cannot be traced down to the common feature of all biological forms, namely, the vital force or the vital phenomenon.

The next question is, how then is the process of evolution of the human society determined? What is its law? To find it, it is necessary to go back as far as possible to the origin of the human society. That can be done in two ways. Firstly, by studying ancient history critically with the object of reconstructing things and events as they really were, from the scrappy and subjectively coloured records which have come down to us. The other method is to study human behaviour in the primitive communities which are still existing in our days, side by side with the most highly developed civilised communities. Indeed, the latter method is

more reliable and has yielded empirical evidence corroborating the theoretical reconstruction of the past done by a critical study of old records.

The study of primitive communities provides the clue to the enquiry into the causes of the evolution of human society. The observation of the lives and behaviours of primitive human beings renders untenable the assumption that there is a super-human impulse behind all human behaviours. It has been proved that there is no such thing as immutable human nature. For example, one of the time-honoured dictums is that to believe is human. Anthropological investigations have led to the discovery that the idea of God, the belief in an immortal soul or in anything super-natural, is completely absent among primitive human communities. As a matter of fact, a critical examination of what is known as superstition or prejudice (such as magic) has led to the very surprising result that the primitive man is a rationalist. Animism and magic are the spiritual equipments of the primitive man. Both are essentially instinctive determinism.

It is that rationalist instinct which persuaded man to congregate in communities. Human society originated in the instinct of self-preservation which is best guaranteed by collective efforts. If the primitive man believed in a super-natural power, then he would not feel the necessity for seeking mutual protection from a communal life. In that

case, he would live as an individual anywhere, remaining in communion only with the Divine, just as many holy men do even in our days. But the fact is that the instinct of self-preservation persuaded the primitive man to live in herds. That was not an instinct for spiritual elevation, but of physical self-preservation.

Thus, it is quite legitimate to say that selfishness is the governing human instinct. Man is selfish by nature. I am treading on a dangerous ground. Selfishness has aquired a very narrow meaning. But that is the meaning of the vulgar. We are engaged in a scientific study, and terms used have only scientific connotation. Selfishness means concern for one's self. There is absolutely nothing wrong in it. In order to be anything or do anything, one must exist. As soon as the primitive man realises that he can exist more comfortably in the company of others, the evolution of human society begins. The individual self merges in a group; his selfishness becomes the concern for the welfare of the entire community. Because the individual interest is promoted by collective interest, individual selfishness becomes collective selfishness.

These fundamental facts of human existence have been confused by other preoccupations which took possession of man's mind in course of social evolution. The idea of asceticism has been sublimated not only in our country, but also in

others in the past. It is believed that to renounce the pleasures of life, to retire for contemplating things divine, is a meritorious behaviour; that by doing so man rises above the material existence. But a critical study of that attitude leads to an entirely different conclusion. It may be regarded as a higher form of selfishness, inasmuch as the individual self, instead of merging into the collective self, refuses to shoulder the collective responsibility, to subordinate its own self to the communal self. As a matter of fact, that is real selfishness, in the vulgar sense. It is a negation of the fundamental human instinct of self-preservation. This sort of selfishness is called egotism. It means that the individual welfare is placed above the general welfare.

Soon after human society originated in the instinct of self-preservation, the original instinct was reinforced by a new instinct. It was the instinct of progress. The term progress has also been given a sort of metaphysical meaning. If progress is conceived as an immeasurable, metaphysical category, the conception does not take us very far. So, the term must be defined scientifically. I define it as the conquest of nature by man. To the extent man conquers nature, to that extent he progresses. The origin of the instinct of progress can be traced to an accident, which however, being an event in the process of self-preservation, is not really an accident.

The problem of the missing link between man and the ape has been solved by the discovery that there are points in the process of biological evolution also where quantitative changes become qualitative changes. That is called mutation. Scientific enquiry has not yet discovered a biological form intervening between the anthropoid ape and man. Perhaps the gap will be filled up by some future discovery. Meanwhile the problem has been solved in a different way. Empirical evidence is no longer essential. The gap can be filled up logically, if not yet ontologically. It has been established that evolution is not an unbroken chain. Mutation takes place not only in one particular point of organic evolution. It may take place in many points. Therefore, it is legitimate to assume that the absence of the so-called missing link is most probably due to mutation, that is, a sudden jump.

It can be easily imagined how such a jump took place. One of our ancestors, in course of their struggle for existence in the primeval forests, might have suddenly discovered that, if he could break a branch from a tree, immediately the length of his arm was increased. Weapon might have originated thus in an accidental act of some immediate ancestor of man. Purely biological evolution is determined by the necessity of adjusting the organism to its environments. As soon

as, in the struggle for existence, an organism can be benefitted by the acquisition of something, which is not a part of itself, a qualitative change takes place in the process of biological evolution. Most probably by that mutation in his behaviour, the anthropoid ape becomes the first ancestor of a new species, namely, mankind. At the same time, the ability to increase his power with the help of an external object represents the first conquest of man over nature, and opens up the new process of evolution called human progress. By experience it was found that the ability to utilise certain things outside his physical organism enabled the primitive man to have greater success in the struggle for existence. One step further, and it was realised that, if the effort was made collectively, the success would be still greater.

The original human communities were formed, on the one hand, to defend themselves, and, on the other hand, to pool individual resources for conducting the struggle for existence with greater success. They went through successive stages, in course of which the means and methods of earning livelihood were progressively improved. Ultimately, they reached the stage when they settled down on land. Until then, they had to run after animals which must be killed for food. That primitive age of nomadic existence might have lasted very long. The cultivation of land for making it bear fruit recurringly was the foundation of stable human communities.

The next great jump in the process of social evolution was caused by the domestication of animals. Previous to that, in the struggle for existence, human communities had to depend entirely on their own energies. Domestication of animals relieved a part of their energy from the labour of earning the bare means of subsistence. A great revolution took place in human society. For the first time, man came to have some leisure time which could be devoted for his development in other directions. That was the origin of what are called peculiar human faculties.

As long as human being had to devote his entire energy and time to the sole occupation of earning the bare means of subsistence, he was very little differentiated from the lower animals. Only when he could earn his livelihood by employing a fraction of his time and energy, he began to acquire the faculty to cultivate the so-called finer aspects of human existence.

This brief analysis of the evolution of prehistoric human society enables us to come to the conclusion that social evolution as a whole is not teleological; that it is governed by physical laws, that is to say, by laws inherent in human existence itself. They do not transcend the limits of human existence, and therefore cannot be traced to any super-human or super-natural source. Being only a higher form of organism, man is a part of the physical nature. Therefore, his evolution

must be governed by the fundamental laws of the physical world. But there are certain fundamental laws which govern the general being and becoming of the entire physical world including human existence; on the other hand, there are special laws operative in different departments of the physical world, governing special manifestations of the general physical existence. As a part of the entire scheme of the physical world, human society, in the last analysis, is subject to the fundamental laws of nature; but it has its own special laws, which nevertheless are inherent in itself as an integral part of the physical world. They did not exist before the establishment of human society. Therefore, they cannot be traced to any super-human or pre-human cause.

When all this is said, there still remains the fact that human society and its history do appear to be such a chaotic jumble of events that it is very difficult to believe that they are really governed by any law. It may appear like that, but in reality it is not a chaos. However, the same objection could be raised perhaps more pertinently against the teleological view. If everything is happening according to an intelligent purpose, a providential plan, why everything does not happen more methodically; why there is so much waste which can be justified only by assuming that it is a process of recurring trials and errors. A plan predetermined by the omniscient and

omnipotent Divine Will should work out differently.

The laws of human society are deterministic laws and can be reduced to one fundamental law. If that fundamental law is found to be a physical law, then, the time-honoured teleological view of history can be definitely rejected. This was not done until very recently. Until then, no effort was made to discover some guiding principle underlying the kaleidoscopic panorama of human society. History was taken as it was handed down from generation to generation—as a legend. When the development of modern science enabled man to undertake an investigation into the structure of contemporary society, the scientific method compelled them to go step by step, and gradually come up against the problem of one fundamental law of human development.

Human society has progressed from one stage to another. There were the antique-patriarchal and the mediaeval-monarchical societies with intermediate stages. But why did those changes take place? Until recently, no scientifically convincing answer was available. One had to simply start from an assumption.

In order to find the answer, we must again go back to the primitive society, because there the problem is not so complex, and phenomena could be studied in their simplicity. There it is possible to apply the scientific method of isolation. That

investigation has led to the conclusion that the ever changing standards of human behaviour, the circumstances of living, the structure of society, the successive stages of social evolution—all these are determined by one factor, namely, the mode in which the particular community makes its livelihood.

It has already been seen that, as soon as a human community finds it possible to earn its livelihood by spending only a fraction of time and collective energy, it enters into a new stage of development. In the new stage, the mode of earning livelihood is determined by the instruments or tools of the epoch. A community possessing instruments or tools which enable it to earn its livelihood with less time and energy, progresses more quickly, and establishes greater domination over its natural environments. Those factors determine the uneven evolution of human society. One community goes ahead, while others may lag behind.

In the beginning, the primitive human community was a homogeneous body; the individual ego was completely submerged in the collective ego. Labour was performed collectively, and the produce used collectively. But with the domestication of animals, and more intensive cultivation of land, the more favourably situated community came to be in possession of more and more leisure. Only in a higher stage of social evolution, leisure is utilised for cultivating the finer aspects of human life. In

the earlier stages, it is utilised to go further in the struggle against nature. At that stage, leisure enabled human beings to improve their instruments and invent new ones. Gradually, instruments were manufactured by individuals and became the possession of those manufacturing them. Previously, land and cattle were collectively owned. Possession of other instruments enabled individuals to devote their energy, released from the cultivation of land thanks to the domestication of animals, to other occupations. The most minimum physical necessities of all were satisfied by the product of collective labour performed during a part of the day. The rest of the time was devoted by individuals to new subsidiary occupations. Whatever was produced by individual labour, came to be the private property of the producer. The land was still cultivated collectively. Therefore, nobody could claim a certain part of its produce as belonging to him personally. But when an individual killed an animal with a weapon belonging to himself, he could legitimately claim it as his own. The origin of private property created yet another great revolution in the evolution of human society. Ultimately, the homogeneous primitive society broke up.

The forces operating in the contemporary society can be properly understood and the perspective of future developments can be clearly visualised, when we bear in mind that the instinct of self-preservation and the urge for progress are the

governing factors of the entire process of the evolution of human society. The view that the history of human society, since the dissolution of primitive communism, is a history of class struggle appears far-fetched and dogmatic only to those who try to explain human behaviour and social events on the basis of metaphysical assumptions. Those who dispute the theory of class struggle maintain that human beings naturally desire to live in harmony because the same spiritual or moral force expresses itself through them all. From this assumption, they go on to assert that it is only selfishness, exaggerated importance attached to the welfare of physical life, that compels human beings to forget their real nature, and thus get involved into conflicts and discords. The knowledge about the origin of human society refutes this doctrine. The original human instinct is selfishness, in the sense of self-preservation. That being the case, we cannot simply brush aside rude and disagreeable realities as something imaginary or the creation of perverse brains, only because they do not fit into our preconceived ideas or pet notions.

There are people who maintain that India, in any case, is an exception. She has never known class struggle, social harmony having been the characteristic feature of Indian culture. They go to the extent of saying that even to-day there is no class struggle in India, and maintain that only a few misguided men have introduced this ugly

feature in this country, having been corrupted by the materialistic view of the West. We need only look at the realities of the contemporary situation, to ascertain how much truth is there in all this wisdom. Contemporary Indian society is evidently not a homogeneous whole; like any other human community, it is composed of different groups, the behaviour of each group being determined by the original, fundamental law of human nature, namely, selfishness. Let it be emphasised once again that it is not the selfishness of an individual. An entire section of the society has one interest. The selfishness of every individual belonging to that section is submerged into its collective selfishness. The collective selfishness of different groups clashes. All are human groups. The interest of which group should prevail? The question is easily answered if we bear in mind the other fundamental law of social evolution, namely, the urge for progress. In a given period of history, the interest of one section of the society coincides with the welfare and progress of the whole. Just as individual selfishness is submerged in the collective selfishness of that section because there is no antagonism between the two, similarly, the interest of that particular section being identical with the welfare of the whole, it should not be regarded as selfishness of one particular section, but as representing the instinct of self preservation and the urge for progress of the entire community.

If the Indian Epics and Puranas are studied in the light of this clue to the problem of social evolution, the past of our country presents an entirely different picture. The history of no other country, perhaps, records such a succession of bloody and ruinous class struggles. Perhaps the greatest of civil wars in entire human history was fought at *Kurukshetra.*

To detect some teleological law underlying the process of social evolution, is simply to beg the question. Indeed, the teleological approach to any problem simply puts it off. Instead of answering the question, it raises another. Why should the enquirer stop at the hypothesis that everything happens according to a Providential Will? He is perfectly justified in asking, why did the Providence will that everything should happen only in this way and not in any other way? Then, there is the dogma of a Final Cause. Why should any cause be final? If everything must have a cause, the Final Cause cannot be free from the necessity of having a cause for itself. Any other explanation than an explanation which enables us to put our finger on something which is self-explained, is no explanation at all. The teleological view does not offer such an explanation. It obliges us to end in an assumption which has no other ground than blind faith. The scientific, materialistic, approach to the problems of human development does not compel us to stop with any arbitrary assumption, and sets up

no other authority than that of positive, verifiable, knowledge. A determinist law is inherent in the organism which it determines. The organism is there before us to observe. If all its operations could be explained by laws which can be themselves derived from the simple existence of the organism, then, the entire complex of problems is solved without any auxiliary hypothesis. The mechanistic view of the evolution of human society is convincing because it does not require an external sanction for the explanation it gives.

Science has established conclusively that human being emerged from the long process of organic evolution. No one can indicate the point where something external was interjected in that process. On the other hand, the process can be traced down to a point where it merges in the inanimate substratum of the physical world. Lately, there has been some unwarranted speculation about the nature of that substratum. But whatever it may be, all human and social phenomena are causally connected with it. To trace that causal connection, it is not necessary to assume the intervention of anything from outside the scheme of the physical world. Like all the laws of the physical world, the laws of social evolution are sovereign; they operate by themselves. If in the past human beings and communities developed by virtue of the potentialities inherent in themselves, in the future also the process will be equally independent of any external influence. What

is still more significant is that, the future development being determined by the forces operative at the present, a scientific study of the latter should enable us to visualise the perspective of future development. As soon as it will be possible to control the environments in which human beings live to-day, so as to remove all the limitations under which they still suffer, as soon as we shall have established still greater dominion over the forces of nature, human nature will again change, and men of science, learning, culture will no longer be exceptions, but the average citizen of a future human society.

The discovery of the fundamental law of history, and the knowledge that it is a deterministic law inherent in the social organism itself, open up an endless perspective of human evolution, and establishes the sovereignty of man. For the first time, man can call himself the maker of his own destiny.

What is stated above in brief is the philosophy of Materialism. In India, the term materialism is used in a deprecative sense. But this materialistic view of history alone enables us to have a perspective of the future in which the spiritual potentialities of man will be freely unfolded, when man will not live so near to animalness as the majority of mankind still do to-day, where the satisfaction of true spiritual needs and aspirations will be available to all.

CHAPTER I

MAGIC AND RELIGION

BY SIR JAMES FRAZER

WHEREVER sympathetic magic occurs in its pure unadulterated form, it assumes that in nature one event follows another necessarily and invariably without the intervention of any spiritual or personal agency. Thus its fundamental conception is identical with that of modern science; underlying the whole system is a faith, implicit but real and firm, in the order and uniformity of nature. The magician does not doubt that the same causes will always produce the same effects, that the performance of the proper ceremony, accompanied by the appropriate spell, will inevitably be attended by the desired results, unless, indeed, his incantations should chance to be thwarted and foiled by the more potent charms of another sorcerer. He supplicates no higher power; he sues the favour of no fickle and wayward being; he abases himself before no lawful deity. Yet his power, great as he believes it to be, is by no means arbitrary and unlimited. He can wield it only so long as he strictly conforms to

the rules of his art, or to what may be called the laws of nature as conceived by him. To neglect these rules, to break these laws in the smallest particular is to incur failure, and may even expose the unskillful practitioner himself to the utmost peril. If he claims a sovereignty over nature, it is a constitutional sovereignty rigorously limited in its scope and exercised in exact conformity with ancient usage. Thus the analogy between the magical and the scientific conceptions of the world is close. In both of them the succession of events is perfectly regular and certain, being determined by immutable laws, the operation of which can be foreseen and calculated precisely; the elements of caprice, of chance, and of accident are banished from the course of nature. Both of them open up a seemingly boundless vista of possibilities to him who knows the causes of things and can touch the secret springs that set in motion the vast and intricate mechanism of the world. Hence the strong attraction which magic and science alike have exercised on the human mind; hence the powerful stimulus that both have given to the pursuit of knowledge. They lure the weary inquirer, the footsore seeker, on through the wilderness of disappointment in the present by their endless promises of the future; they take him up to the top of an exceedingly high mountain and show him, beyond the dark clouds and rolling mists at his feet, a vision of the celestial city, far off, it may

be, but radiant with unearthly splendour, bathed in the light of dreams.

The fatal flaw of magic lies not in its general assumption of a succession of events determined by law, but in its total misconception of the nature of the particular laws which govern that succession. If we analyse the various cases of sympathetic magic, we shall find them to be all mistaken applications of one or other of two great fundamental laws of thought, namely, the association of ideas by similarity and the association of ideas by contiguity in space or time. A mistaken association of similar ideas produces imitative or mimetic magic; a mistaken association of contiguous ideas produces sympathetic magic in the narrower sense of the word. The principles of association are excellent in themselves, and indeed absolutely essential to the working of the human mind. Legitimately applied, they yield science; illegitimately applied, they yield magic, the bastard sister of science. It is therefore a truism, almost a tautology, to say that all magic is necessarily false and barren; for were it ever to become true and fruitful, it would no longer be magic but science. From the earliest times man has been engaged in a search for general rules whereby to turn the order of natural phenomena to his own advantage, and in the long search he has scraped together a great hoard of such maxims, some of them golden and some of them mere

dross. The true or golden rules constitute the body of applied science; the false are magic.

If magic is thus next of kin to science, we have still to inquire how it stands related to religion. But the view we take of that relation will necessarily be coloured by the idea which we have formed of the nature of religion itself; hence a writer may reasonably be expected to define his conception of religion before he proceeds to investigate its relation to magic. There is probably no subject in the world about which opinions differ so much as the nature of religion, and to frame a definition of it which would satisfy everyone must obviously be impossible. All that a writer can do is, first to say clearly what he means by religion, and afterwards to employ the word consistently in that sense throughout his work. *By religion, then, I understand a propitiation or conciliation of powers superior to man which are believed to direct and control the course of nature and of human life.* In this sense it will readily be perceived that *religion is opposed in principle both to magic and to science.* For all conciliation implies that the being conciliated is a conscious or personal agent, that his conduct is in some measure uncertain, and that he can be prevailed upon to vary it in the desired direction by a judicious appeal to his interests, his appetites, or his emotions. Conciliation is never employed towards things which are regarded as inanimate, nor towards persons whose behaviour in the

particular circumstances is known to be determined with absolute certainty. Thus in so far as religion assumes the world to be directed by conscious agents who may be turned from their purpose by persuasion, it stands in fundamental antagonism to magic as well as to science, both of which take for granted that the course of nature is determined, not by the passions or caprice of personal beings, but by the operation of immutable laws acting mechanically. In magic, indeed, the assumption is only implicit, but in science it is explicit. It is true that magic often deals with spirits, which are personal agents of the kind assumed by religion; but whenever it does so in its proper form, it treats them exactly in the same fashion as it treats inanimate agents, that is, it constrains or coerces, instead of conciliating or propitiating them as religion would do. In ancient Egypt, for example, the magicians claimed the power of compelling even the highest gods to do their bidding, and actually threatened them with destruction in case of disobedience. This radical conflict of principle between magic and religion sufficiently explains the relentless hostility with which in history the priest has often pursued the magician. The haughty self-sufficiency of the magician, his arrogant demeanour towards the higher powers, and his unabashed claim to exercise a sway like theirs could not but revolt the priest, to whom, with his awful sense of the divine majesty, and his humble prostration in presence of it, such

claims and such a demeanour must have appeared an impious and blasphemous usurpation of prerogatives that belong to God alone. And sometimes, we may suspect, lower motives concurred to whet the edge of the priest's hostility. He professed to be the proper medium, the true intercessor between God and man, and no doubt his interests as well as his feelings were often injured by a rival practitioner, who preached a surer and smoother road to fortune than the rugged and slippery path of divine favour.

Yet this antagonism, familiar as it is to us, seems to have made its appearance comparatively late in the history of religion. At an earlier stage the functions of priest and sorcerer were often combined or, to speak perhaps more correctly, were not yet differentiated from each other. To serve his purpose man wooed the good-will of gods or spirits by prayer and sacrifice, while at the same time he had recourse to ceremonies and forms of words which he hoped would of themselves bring about the desired result without the help of god or devil. In short, he performed religious and magical rites simultaneously; he uttered prayers and incantations almost in the same breath, knowing or reckoning little of the theoretical inconsistency of his behaviour, so long as by hook or crook he contrived to get what he wanted. Instances of this fusion or confusion of magic with religion have already met us in the practices of Melanesians and of some East Indian islanders.

So far as the Melanesians are concerned, the general confusion cannot be better described than in the words of Dr. R. H. Codrington: "That invisible power which is believed by the natives to cause all such effects as transcend their conception of the regular course of nature, and so reside in spiritual beings, whether in the spiritual part of living men or in the ghosts of the dead, being imparted by them to their names and to various things that belong to them, such as stones, snakes, and indeed objects of all sorts, is that generally known as *mana*. Without some understanding of this it is impossible to understand the religious beliefs and practices of the Melanesians; and this again is the active force in all they do and believe to be done in magic, white or black. By means of this men are able to control or direct the forces of nature, to make rain or sunshine, wind or calm, to cause sickness or remove it, to know what is far off in time and space, to bring good luck and prosperity, or to blast and curse. By whatever name it is called, it is the belief in this supernatural power, and in the efficacy of the various means by which spirits and ghosts can be induced to exercise it for the benefit of men, that is the foundation of the rites and practices which can be called religious; and it is from the same belief that everything which may be called Magic and Witchcraft draws its origin. Wizards, doctors, weather-mongers, prophets, diviners, dreamers, all alike, everywhere in the islands, work by this power.

There are many of these who may be said to exercise their art as a profession ; they get their property and influence in this way. Every considerable village or settlement is sure to have someone who can control the weather and the waves, someone who knows how to treat sickness, someone who can work mischief with various charms. There may be one whose skill extends to all these branches ; but generally one man knows how to do one thing, and one another. This various knowledge is handed down from father to son, in the same way as is the knowledge of the rites and methods of sacrifice and prayer ; and very often the same man who knows the sacrifice knows also the making of the weather and of charms for many purposes besides. But as there is no order of priests, there is also no order of magicians or medicine-men. Almost every man of consideration knows how to approach some ghost or spirit, and has some secret of occult practices."

The same confusion of magic and religion has survived among peoples that have risen to higher levels of culture. It was rife in ancient India and ancient Egypt ; it is by no means extinct among European peasantry at the present day. With regard to ancient India we are told by an eminent Sanscrit scholar that "the sacrificial ritual at the earliest period of which we have detailed information is pervaded with practices that breathe the spirit of the most primitive magic." Again, the same writer observes that "the ritual of the very

sacrifice for which the metrical prayers were composed is described in the other Vedic texts as saturated from beginning to end with magical practices which were to be carried out by the sacrificial priests." In particular, he tells us that the rites celebrated on special occasions, such as marriage, initiation, and the anointment of a king, "are complete models of magic of every kind, and in every case the forms of magic employed bear the stamp of the highest antiquity." Speaking of the importance of magic in the East, and especially in Egypt, Professor Maspero remarks that, "we ought not to attach to the word magic the degrading idea which it almost inevitably calls up in the mind of a modern. Ancient magic was the very foundation of religion. The faithful who desired to obtain some favour from a god had no chance of succeeding except by laying hands on the deity, and this arrest could only be effected by means of a certain number of rites, sacrifice, prayers, and chants, which the god himself had revealed, and which obliged him to do what was demanded of him." According to another distinguished Egyptologist, "the belief that there are words and actions by which man can influence all the powers of nature and all living things, from animals up to gods, was inextricably interwoven with everything the Egyptians did and everything they left undone. Above all, the whole system of burial and of the worship of the dead

is completely dominated by it. The wooden puppets which relieved the dead man from toil, the figures of the maid-servants who baked bread for him, the sacrificial formulas by the recitation of which food was procured for him, what are these and all the similar practices but magic? And as men cannot help themselves without magic, so neither can the gods; the gods also wear amulets to protect themselves, and use magic spells to constrain each other." But though we can perceive the union of discrepant elements in the faith and practice of the ancient Egyptians, it would be rash to assume that the people themselves did so. "Egyptian religion," says Professor Widemann, "was not one and homogeneous; it was compounded of the most heterogeneous elements, which seemed to the Egyptian to be all equally justified. He did not care whether a doctrine or a myth belonged to what we should call faith or superstition; it was indifferent to him whether we should rank it as religion or magic, as worship or sorcery. All such classifications were foreign to the Egyptian. To him no one doctrine seemed more or less justified than another. Nay, he went so far as to allow the most flagrant contradictions to stand peaceably side by side."

Among the ignorant classes of modern Europe the same confusion of ideas, the same mixture of religion and magic, crops up in various forms. Thus we are told that in France, "the majority of the

peasants still believe that the priest possesses a secret and irresistible power over the elements. By reciting certain prayers which he alone knows and has the right to utter, yet for the utterance of which he must afterwards demand absolution, he can on an occasion of pressing danger, arrest or reverse for a moment the action of the eternal laws of the physical world. The winds, the storms, the hail, and the rain are at his will. The fire also is subject to him, and the flames of a conflagration are extinguished at his word." For example, French peasants used to be, perhaps are still, persuaded that the priests could celebrate, with certain special rites, "a Mass of the Holy Spirit," of which the efficacy was so miraculous that it never met with any opposition from the divine will; God was forced to grant whatever was asked of Him in this form, however rash and importunate might be the petition. No idea of impiety or irreverence attached to the rite in the minds of those who, in some of the great extremities of life, sought by this singular means to take the kingdom of heaven by storm. The secular priests generally refused to say the "Mass of the Holy Spirit"; but the monks, especially the Capuchin friars, had the reputation of yielding with less scruple to the entreaties of the anxious and distressed. In the constraint thus supposed by Catholic peasantry to be laid by the priest upon the deity we seem to have an exact counterpart of the power which, as we saw, the ancient Egyptians ascribed to

their magicians. Again, to take another example, in many villages of Provence the priest is still reputed to possess the faculty of averting storms. It is not every priest who enjoys this reputation; and in some villages when a change of pastors takes place, the parishioners are eager to learn whether the new incumbent has the power. At the first sign of a heavy storm they put him to the proof by inviting him to exorcise the threatening clouds; and if the result answers to their hopes, the new shepherd is assured of the sympathy and respect of his flock. In some parishes, where the reputation of the curate in this respect stood higher than that of his rector, the relations between the two have been so strained in consequence, that the bishop has had to translate the rector to another benefice.

Yet though magic is thus found to fuse and amalgamate with religion in many ages and in many lands, there are some grounds for thinking that this fusion is not primitive, and that there was a time when man trusted to magic alone for the satisfaction of such wants as transcended his immediate animal cravings. In the first place a consideration of the fundamental notions of magic and religion may incline us to surmise that magic is older than religion in the history of humanity. We have seen that on the one hand, magic is nothing but a mistaken application of the very simplest and most elementary processes of the mind, namely, the association of ideas by virtue of resemblance or

contiguity; and on the other hand, that religion assumes the operation of conscious or personal agents, superior to man, behind the visible screen of nature. Obviously the conception of personal agents is more complex than a simple recognition of the similarity or contiguity of ideas; and a theory which assumes that the course of nature is determined by conscious agents is more abstruse and recondite, and requires for its apprehension a far higher degree of intelligence and reflection than the view that things succeed each other simply by reason of their contiguity or resemblance. The very beasts associate the ideas of things that are like each other or that have been found together in their experience; and they could hardly survive for a day if they ceased to do so. But who attributes to the animals a belief that the phenomena of nature are worked by a multitude of invisible animals or by one enormous and prodigiously strong animal behind the scenes? It is probably no injustice to the brutes to assume that the honour of devising a theory of this latter sort must be reserved for human reason. Thus if magic be deduced immediately from elementary processes of reasoning, and be, in fact, an error into which the mind falls almost spontaneously, while religion rests on conceptions which the merely animal intelligence can hardly be supposed to have yet attained to, it becomes probable that magic arose before religion in the evolution of our race, and that man essayed to bend

nature to his wishes by the sheer force of spells and enchantments before he strove to coax and mollify a coy, capricious, or irascible deity by the soft insinuation of prayer and sacrifice.

The conclusion which we have thus reached deductively from a consideration of the fundamental ideas of religion and magic is confirmed inductively by what we know of the lowest existing race of mankind. To the student who investigates the development of vegetable and animal life on our globe, Australia serves as a sort of museum of the past, a region in which strange species of plants and animals, representing types that have long been extinct elsewhere, may still be seen living and thriving, as if on purpose to satisfy the curiosity of these later ages as to the fauna and flora of the antique world. This singularity Australia owes to the comparative smallness of its area, the waterless and desert character of a large part of its surface, and its remote situation, severed by wide oceans from the other and greater continents. The same causes which have favoured the survival of antiquated types of plants and animals in Australia, have conserved the aboriginal race at a lower level of mental and social development than is now occupied by any other set of human beings spread over an equal area elsewhere. Without metals, without houses, without agriculture, the Australian savages represent the stage of material culture which was reached by our remote ancestors in the Stone

Age; and the rudimentary state of the arts of life among them reflects faithfully the stunted condition of their minds. Now in regard to the question of the respective priority of magic or religion in the evolution of thought, it is very important to observe that among these savages, while magic is universally practised, religion in the sense of a propitiation or conciliation of the higher powers seems to be nearly unknown. Roughly speaking, all men in Australia are magicians, but not one is a priest; everybody fancies he can influence his fellows or the course of nature by sympathetic magic, but nobody dreams of propitiating gods or spirits by prayer and sacrifice.

"It may be truly affirmed," says a recent writer on the Australians, "that there was not a solitary native who did not believe as firmly in the power of sorcery as in his own existence; and while anybody could practise it to a limited extent, there were in every community a few men who excelled in pretension to skill in the community; by unanimous consent the whites have called them 'doctors' and they correspond to the medicine men and rainmakers of other barbarous nations. The power of the doctor is only circumscribed by the range of his fancy. He communes with spirits, takes aerial flights at pleasure, kills or cures, is invulnerable and invisible at will, and controls the elements."

But if in the most primitive state of human society now open to observation on the globe we

find magic thus conspicuously present and religion conspicuously absent, may we not reasonably con jecture that the civilised races of the world have also at some period of their history passed through a similar intellectual phase, that they attempted to force the great powers of nature to do their pleasure before they thought of courting their favour by offering and prayer—in short that, just as on the material side of human culture there has everywhere been an Age of Stone, so on the intellectual side there has everywhere been an Age of Magic? There are reasons for answering this question in the affirmative. When we survey the existing races of mankind from Greenland to Tierra del Fuego, or from Scotland to Singapore, we observe that they are distinguished one from the other by a great variety of religions, and that these distinctions are not, so to speak, merely conterminous with the broad distinctions of race, but descend into the minuter sub-divisions of states and commonwealth, nay, that they honeycomb the town, the village, and even the family, so that the surface of society all over the world is cracked and seamed, wormed and sapped with rents and fissures and yawning crevasses opened up by the disintegrating influence of religious dissension. Yet when we have penetrated through these differences, which affect mainly the intelligent and thoughtful part of the community, we shall find underlying them all a solid stratum of intellectual agreement

among the dull, the weak, the ignorant, and the superstitious, who constitute, unfortunately, the vast majority of mankind. One of the great achievements of the century which is now nearing its end, is to have run shafts down into this low mental stratum in many parts of the world, and thus to have discovered its substantial identity everywhere. It is beneath our feet—and not very far beneath them—here in Europe at the present day, and it crops up on the surface in the heart of the Australian wilderness and wherever the advent of a higher civilisation has not crushed it underground. This universal faith, this truly Catholic creed, is a belief in the efficacy of magic. While religious systems differ not only in different countries, but in the same country in different ages, the system of sympathetic magic remains everywhere and at all times substantially alike in its principles and practice. Among the ignorant and superstitious classes of modern Europe, it is very much what it was thousands of years ago in Egypt and India, and what it now is among the lowest savages surviving in the remotest corners of the world. If the test of truth lay in a show of hands or a counting of heads, the system of magic might appeal, with far more reason than the Catholic Church, to the proud motto, "Quod semper, quod ubique, quod ab omnibus,"* as the sure and certain credential of its own infallibility.

* "Which is always, everywhere and of all."

It is not our business here to consider what bearing the permanent existence of such a solid layer of savagery beneath the surface of society, and unaffected by the superficial changes of religion and culture, has upon the future of humanity. The dispassionate observer, whose studies have led him to plumb its depths, can hardly regard it otherwise than as a standing menace to civilisation. We seem to move on a thin crust which may at any moment be rent by the subterranean forces slumbering below. From time to time a hollow murmur underground or a sudden spit of flame into the air tells of what is going on beneath our feet. Now and then the polite world is startled by a paragraph in a newspaper which tells how in Scotland an image has been found stuck full of pins for the purpose of killing an obnoxious laird or minister; how a woman has been slowly roasted to death as a witch in Ireland, or how a girl has been murdered and chopped up in Russia to make those candles of human tallow by whose light thieves hope to pursue their midnight trade unseen. But whether the influences that make for further progress, or those that threaten to undo what has already been accomplished, will ultimately prevail; whether the kinetic energy of the minority or the dead weight of the majority of mankind will prove the stronger force to carry us up to higher heights or to sink us into lower depths, are questions rather for the sage, the moralist, and the statesman, whose eagle vision scans the future, than for the

humble student of the present and the past. Here we are only concerned to ask how far the uniformity, the universality, and the permanence of a belief in magic, compared with the endless variety and the shifting character of religious creeds, raises a presumption that the former represents a ruder and earlier phase of the human mind, through which all the races of mankind have passed or are passing on their way to religion and science.

If an Age of Religion has thus everywhere, as I venture to surmise, been preceded by an Age of Magic, it is natural that we should inquire what causes have led mankind, or rather a portion of them, to abandon magic as a principle of faith and practice and to betake themselves to religion instead. When we reflect upon the multitude, the variety, and the complexity of the facts to be explained, and the scantiness of our information regarding them, we shall be ready to acknowledge that a full and satisfactory solution of so profound a problem is hardly to be hoped for, and that the most we can do in the present state of our knowledge is to hazard a more or less plausible conjecture. With all due diffidence, then, I would suggest that a tardy recognition of the inherent falsehood and barrenness of magic set the more thoughtful part of mankind to cast about for a truer theory of nature and a more fruitful method of turning her resources to account. The shrewder intelligences must in time have come to perceive that magical ceremonies and incantations did not

really effect the results which they were designed to produce, and which the majority of their simpler fellows still believed that they did actually produce. This great discovery of the inefficacy of magic must have wrought a radical though probably slow revolution in the minds of those who had the sagacity to make it. The discovery amounted to this, that men for the first time recognised their inability to manipulate at pleasure certain natural forces which hitherto they had believed to be completely within their control. It was a confession of human ignorance and weakness. Man saw that he had taken for causes what were no causes, and that all his efforts to work by means of these imaginary causes had been vain. His painful toil had been wasted, his curious ingenuity had been squandered to no purpose. He had been pulling at strings to which nothing was attached; he had been marching, as he thought, straight to his goal, while in reality he had only been treading in a narrow circle. Not that the effects which he had striven so hard to produce did not continue to manifest themselves. They were still produced, but not by him. The rain still fell on the thirsty ground; the sun still pursued his daily, and the moon her nightly journey across the sky; the silent procession of the seasons still moved in light and shadow, in cloud and sunshine across the earth; men were still born to labour and sorrow, and still after a brief sojourn here, were gathered to their fathers in the long home

hereafter. All things indeed went on as before, yet all seemed different to him from whose eyes the old scales had fallen. For he could no longer cherish the pleasing illusion that it was he who guided the earth and the heaven in their courses, and that they would cease to perform their great revolutions were he to take his feeble hand from the wheel. In the death of his enemies and his friends he no longer saw a proof of the resistless potency of his own or of hostile enchantments; he now knew that friends and foes alike had succumbed to a force stronger than any that he could wield, and in obedience to a destiny which he was powerless to control.

Thus cut adrift from his ancient moorings and left to toss on a troubled sea of doubt and uncertainty, his old happy confidence in himself and his powers rudely shaken, our primitive philosopher must have been sadly perplexed and agitated till he came to rest, as in a quiet haven after a tempestuous voyage, in a new system of faith and practice, which seemed to offer a solution of his harassing doubts and a substitute, however precarious, for that sovereignty over nature which he had reluctantly abdicated. If the great world went on its way without the help of him or his fellows, it must surely be because there were other beings, like himself but far stronger, who, unseen themselves, directed its course and brought about all the varied series of events which he had hitherto believed to

be dependent on his own magic. It was they, as he now believed, and not he himself, who made the stormy wind to blow, the lightning to flash and the thunder to roll; who had laid the foundations of the solid earth and set bounds to the restless sea that it might not pass; who caused all the glorious lights of heaven to shine; who gave the fowls of the air their meat and the wild beasts of the desert their prey; who bade the fruitful land to bring forth in abundance, the high hills to be clothed with forests, the bubbling springs to rise under the rocks in the valleys, and the green pastures to grow by still waters; who breathed into man's nostrils and made him live, or turned him to destruction by famine and pestilence and war. To these mighty beings, whose handiwork he traced in all the gorgeous and varied pageantry of nature, man now addressed himself, humbly confessing his dependence on their invisible power, and beseeching them of their mercy to furnish him with all good things, to defend him from the perils and dangers by which our mortal life is compassed about on every hand, and finally to bring his immortal spirit, freed from the burden of the body, to some happier world beyond the reach of pain and sorrow, where he might rest with them and with the spirits of good men in joy and felicity forever.

In this, or some such way as this, the deeper minds may be conceived to have made the great transition from magic to religion. But even in them

the change can hardly ever have been sudden; probably it proceeded very slowly, and required long ages for its more or less perfect accomplishment. For the recognition of man's powerlessness to influence the course of nature on a grand scale must have been gradual; he cannot have been shorn of the whole of his fancied dominion at a blow. Step by step he must have been driven back from his proud position; foot by foot he must have yielded, with a sigh, the ground which he had once viewed as his own. Now it would be the wind, now the rain, now the sunshine, now the thunder, that he confessed himself unable to wield at will; and as province after province of nature thus fell from his grasp, till what had once seemed a kingdom threatened to shrink into a prison, man must have been more and more profoundly impressed with a sense of his own helplessness and the might of the invisible beings by whom he believed himself to be surrounded. Thus religion, beginning as a slight and partial acknowledgment of powers superior to man, tends with the growth of knowledge to deepen into a confession of man's entire and absolute dependence on the divine; his old free bearing is exchanged for an attitude of lowliest prostration before the mysterious powers of the unseen. But this deepening sense of religion, this more perfect submission to the divine will in all things, affects only those higher intelligences who have breadth of view enough to comprehend the vastness of the universe and the littleness of men.

Small minds cannot grasp great ideas; to their narrow comprehension, their purblind vision, nothing seems really great and important but them selves. Such minds hardly rise into religion at all. They are, indeed, drilled by their betters into an outward conformity with its precepts and a verbal profession of its tenets; but at heart they cling to their old magical superstitions, which may be discountenanced and forbidden, but cannot be eradicated by religion, so long as they have their roots deep down in the mental framework and constitution of the great majority of mankind:

The reader may well be tempted to ask, How was it that intelligent men did not sooner detect the fallacy of magic? How could they continue to cherish expectations that were invariably doomed to disappointment? With what heart persist in playing venerable antics that led to nothing, and mumbling solemn balderdash that remained without effect? Why cling to beliefs which were so flatly contradicted by experience? How dare to repeat experiments that had failed so often? The answer seems to be that the fallacy was far from easy to detect, the failure by no means obvious, since in many, perhaps in most cases, the desired event did actually follow, at a longer or shorter interval, the performance of the rite which was designed to bring it about; and a mind of more than common acuteness was needed to perceive that, even in these cases, the rite was not necessarily the cause of the event. A ceremony

intended to make the wind blow or the rain fall, or to work the death of an enemy, will always be followed, sooner or later, by the occurrence it is meant to bring to pass; and primitive man may be excused for regarding the occurrence as a direct result of the ceremony and the best possible proof of its efficacy. Similarly, rites observed in the morning to help the sun to rise, and in spring to wake the dreaming earth from her winter sleep, will invariably appear to be crowned with success, at least within the temperate zones; for in these regions the sun lights his golden fire in the east every morning, and year by year the vernal earth decks herself afresh with a rich mantle of green. Hence the practical savage, with his conservative instincts, might well turn a deaf ear to the subtleties of the theoretical doubter, the philosophic radical, who presumed to hint that sunrise and spring might not, after all, be direct consequences of the punctual performance of certain daily or yearly devotions, and that the sun might perhaps continue to rise and trees to blossom though the devotions were occasionally intermitted, or even discontinued altogether. These skeptical doubts would naturally be repelled by the other with scorn and indignation as airy reveries subversive of the faith, and manifestly contradicted by experience. "Can anything be plainer," he might say, "than that I light my two-penny candle on earth and that the sun then kindles his great fire in heaven? I should be glad to know

whether, when I have put on my green robe in spring, the trees do not afterwards do the same? These are facts patent to everybody, and on them I take my stand. I am a plain practical man, not one of your theorists and splitters of hairs and choppers of logic. Theories and speculation and all that may be very well in their way, and I have not the least objection to your indulging in them, provided, of course, you do not put them in practice. But give me leave to stick to facts; then I know where I am." The fallacy of this reasoning is obvious to us, because it happens to deal with facts about which we have long made up our minds. But let an argument of precisely the same calibre be applied to matters which are still under debate, and it may be questioned whether a British audience would not applaud it as sound, and esteem the speaker who used it a safe man—not brilliant or showy, perhaps, but thoroughly sensible and hard-headed. If such reasonings could pass muster among ourselves, need we wonder that they long escaped detection by the savage?

The patient reader may remember—and the impatient reader who has quite forgotten is respectfully reminded—that we were led to plunge into the labyrinth of magic, in which we have wandered for so many pages, by a consideration of two different types of man-god. This is the clue which has guided our devious steps through the maze, and brought us out at last on higher ground, whence,

resting a little by the way, we can look back over the path we have already traversed and forward to the longer and steeper road we have still to climb.

As a result of the foregoing discussion, the two types of human gods may conveniently be distinguished as the religious and the magical man-god respectively. In the former, a being of an order different from and superior to man is supposed to become incarnate, for a longer or a shorter time, in a human body, manifesting his super-human power and knowledge by miracles wrought and prophecies uttered through the medium of the fleshy tabernacle in which he has deigned to take up his abode. This may also appropriately be called the inspired or incarnate type of man-god. In it the human body is merely a frail earthly vessel filled with a divine and immortal spirit. On the other hand, a man-god of the magical sort is nothing but a man who possesses in an unusually high degree powers which most of his fellows arrogate to themselves on a smaller scale; for in rude society there is hardly a person who does not dabble in magic. Thus, whereas a man-god of the former or insipid type derives his divinity from a deity who has stooped to hide his heavenly radiance behind a dull mask of earthly mold, a man-god of the latter type draws his extraordinary power from a certain physical sympathy with nature. He is not merely the receptacle of a divine spirit. His whole being, body and soul, is so delicately attuned to the harmony of the world that

a touch of his hand or a turn of his head may send a thrill vibrating through the universal framework of things; and conversely his divine organism is acutely sensitive to such slight changes of environment as would leave ordinary mortals wholly unaffected. But the line between these two types of man-god, however sharply we may draw it in theory, is seldom to be traced with precision in practice.

When we have seen that in early society men who make no pretence at all of being gods, do nevertheless commonly believe themselves to be invested with powers which to us would seem super-natural, we shall have the less difficulty in comprehending the extraordinary range of powers ascribed to persons who are actually regarded as divine.

CHAPTER II

ANIMISM

BY SIR EDWARD B. TYLOR

I PROPOSE here, under the name of Animism, to investigate the deep-lying doctrine of Spiritual Beings, which embodies the very essence of Spiritualistic as opposed to Materialistic philosophy.

Animism is not a new technical term, though now seldom used. From its special relation to the doctrine of the soul, it will be seen to have a peculiar appropriateness to the view here taken of the mode in which theological ideas have been developed among mankind. The word Spiritualism, though it may be, and sometimes is, used in a general sense, has this obvious defect to us, that it has become the designation of a particular modern sect, who indeed hold extreme spiritualistic views, but cannot be taken as typical representatives of these views in the world at large. The sense of Spiritualism in its wider acceptation, the general belief in spiritual beings, is here given to Animism.

Animism characterises tribes very low in the scale of humanity, and thence ascends, deeply modified in its transmission, but from first to last preserving an unbroken continuity, into the midst of high modern culture. Doctrines adverse to it, so largely held by individuals or schools, are usually due not to early lowness of civilisation, but to later changes in the intellectual course, to divergence from, or rejection of, ancestral faiths; and such newer developments do not affect the present enquiry as to the fundamental religious condition of mankind. Animism is, in fact, the groundwork of the Philosophy of Religion, from that of savages up to that of civilised men. And although it may at first sight seem to afford but a bare and meagre definition of a minimum of religion, it will be found practically sufficient; for where the root is, the branches will generally be produced. It is habitually found that the theory of Animism divides into two great dogmas, forming parts of one consistent doctrine; first, concerning souls of individual creatures, capable of continued existence after the death or destruction of the body; second, concerning other spirits, upward to the rank of powerful deities. Spiritual beings are held to affect or control the events of the material world, and man's life here and hereafter; and it being considered that they hold intercourse with men, and receive pleasure or displeasure from human actions, the

belief in their existence leads naturally, and it might almost be said inevitably, sooner or later to active reverence and propitiation. Thus Animism, in its full development, includes the belief in souls and in a future state, in controlling deities and subordinate spirits, these doctrines practically resulting in some kind of active worship. One great element of religion, that moral element which among the higher nations forms its most vital part, is indeed little represented in the religion of the lower races. It is not that these races have no moral sense or no moral standard, for both are strongly marked among them, if not in formal precept, at least in that traditional consensus of society which we call public opinion, according to which certain actions are held to be good or bad right or wrong. It is that the conjunction of ethics and Animistic philosophy, so intimate and powerful in the higher culture, seems scarcely yet to have begun in the lower. I propose here hardly to touch upon the purely moral aspects of religion, but rather to study the animism of the world so far as it constitutes, as unquestionably it does constitute, an ancient and world-wide philosophy, of which belief is the theory and worship is the practice. Endeavouring to shape the materials for an enquiry hitherto strangely undervalued and neglected, it will now be my task to bring as clearly as may be into view the fundamental animism

of the lower races, and in some slight and broken outline to trace its course into higher regions of civilisation. Here let me state once for all two principal conditions under which the present research is carried on. First, as to the religious doctrines and practices examined, these are treated as belonging to theological systems devised by human reason, without supernatural aid or revelation; in other words, as being developments of Natural Religion. Second, as to the connection between similar ideas and rites in the religions of the savage and the civilised world. While dwelling at some length on doctrines and ceremonies of the lower races, and sometimes particularising for special reasons the related doctrines and ceremonies of the higher nations, it has not seemed my proper task to work out in detail the problems thus suggested among the philosophies and creeds of Christendom. Such applications, extending farthest from the direct scope of a work on primitive culture, are briefly stated in general terms, or touched in slight allusion, or taken for granted without remark. Educated readers possess the information required to work out their general bearing on theology, while more technical discussion is left to philosophers and theologians specially occupied with such arguments.

The first branch of the subject to be considered is the doctrine of human and other souls,

an examination of which will occupy the rest of the present theory of its development. It seems as though thinking men, as yet at a low level of culture, were deeply impressed by two groups of biological problems. In the first place, what is it that makes the difference between a living body and a dead one; what causes waking, sleep trance, disease, death? In the second place, what are those human shapes which appear in dreams and visions? Looking at these two groups of phenomena, the ancient savage philosophers probably made their first step by the obvious inference that every man has two things belonging to him, namely, a life and a phantom. These two are evidently in close connection with the body, the life as enabling it to feel and think and act, the phantom as being its image or second self; both, also, are perceived to be things separable from the body, the life as able to go away and leave it insensible or dead, the phantom as appearing to people at a distance from it. The second step would seem also easy for savages to make, seeing how extremely difficult civilised men have found it to unmake. It is merely to combine the life and the phantom. As both belong to the body, why should they not also belong to one another, and be manifestations of one and the same soul? Let them then be considered as united, and the result is that well-known conception which may be described as an apparitional-soul,

a ghost-soul. This, at any rate, corresponds with the actual conception of the personal soul or spirit among the lower races, which may be defined as follows: It is a thin unsubstantial human image, in its nature a sort of vapour, film, or shadow; the cause of life and thought in the individual it animates; independently possessing the personal consciousness and volition of its corporeal owner, past or present; capable of leaving the body far behind, to flash swiftly from place to place; mostly impalpable and invisible, yet also manifesting physical power, and especially appearing to men waking or asleep as a phantasm separate from the body of which it bears the likeness; continuing to exist and appear to men after the death of that body; able to enter into, possess, and act in the bodies of other men, of animals, and even of things. Though this definition is by no means of universal application, it has sufficient generality to be taken as a standard, modified by more or less divergence among any particular people. Far from these world-wide opinions being arbitrary or conventional products, it is seldom even justifiable to consider their uniformity among distant races as proving communication of any sort. They are doctrines answering in the most forcible way to the plain evidence of men's senses, as interpreted by a fairly consistent and rational primitive philosophy. So well, indeed, does primitive

animism account for the facts of nature, that it has held its place into the higher levels of education. Though classic and mediaeval philosophy modified it much, and modern philosophy has handled it yet more unsparingly, it has so far retained the traces of its original character, that heirlooms of primitive ages may be claimed in the existing psychology of the civilised world. Out of the vast mass of evidence, collected among the most various and distant races of mankind, typical details may now be selected to display the earlier theory of the soul, the relation of the parts of this theory, and the manner in which these parts have been abandoned, modified, or kept up, along the course of culture.

To understand the popular conceptions of the human soul or spirit, it is instructive to notice the words which have been found suitable to express it. The ghost or phantasm seen by the dreamer or the visionary is an unsubstantial form, like a shadow, and thus the familiar term of the *shade* comes in to express the soul.

The act of breathing, so characteristic of the higher animals during life, and coinciding so closely with life in its departure, has been repeatedly and naturally identified with the life or soul itself.

The conception of the soul as breath may be followed up through Semitic and Aryan etymology, and thus into the main streams of the philosophy of

the world. Hebrew shows "breath" passing into all the meanings of life, soul, mind, animal. The same is the history of Sanskrit *Atman* and *Prana*, of Greek *Psyche* and *Pneuma*, of Latin *Animus*, *Anima*, *Spiritus*. So Slavonic *Duch* has developed the meaning of "breath" into that of soul or spirit; and the dialects of Gypsies have this word *Duk* with the meanings of "breath" "spirit" "ghost." German *Geist* and English ghost, too, may possibly have the same original sense of breath. And if any should think such expressions due to mere metaphor, they may judge the strength of the implied connection between breath and spirit by cases of most unequivocal significance.

Among rude races, the original conception of the human soul seems to have been that of ethereality, or vaporous materiality, which has held so large a place in human thought ever since. In fact, the later metaphysical notion of immateriality could scarcely have conveyed any meaning to a savage. It is moreover to be noticed that, as to the whole nature and action of apparitional souls, the lower philosophy escapes various difficulties which down to modern times have perplexed metaphysicians and theologians of the civilised world. Considering the thin ethereal body of the soul to be itself sufficient and suitable for visibility, movement and speech, the primitive animists had no need of additional hypotheses to account for these manifestations,

theological theories such as that immaterial souls have their own vaporous bodies, or occasionally have such vaporous bodies provided for them by supernatural means to enable them to appear as spectres, or that they possess the power of condensing the circumambient air into phantom-like bodies to invest themselves in, or of forming from it vocal instruments. It appears to have been within systematic schools of civilised philosophy that the transcendental definitions of the immaterial soul were obtained, by abstraction from the primitive conception of the ethereal-material soul, so as to reduce it from a physical to a metaphysical entity.

Departing from the body at the time of death, the soul or spirit is considered set free to linger near the tomb, to wander on earth or flit in the air, or to travel to the proper region of spirits—the world beyond the grave. Men do not stop short at the persuasion that death releases the soul to a free and active existence, but they quite logically proceed to assist nature, by slaying men in order to liberate their souls for ghostly uses. Thus there arises one of the most widespread, distinct, and intelligible rites of animistic religion that of funeral human sacrifice for the service of the dead. When a man of rank dies and his soul departs to its own place, wherever and whatever that place may be, it is a rational inference of early philosophy

that souls of attendants, slaves, and wives, put to death at his funeral, will make the same journey and continue their service in the next life, and the argument is frequently stretched further, to include the soul of new victims sacrificed in order that they may enter upon the same ghostly servitude. It will appear from the ethnography of this rite that it is not strongly marked in the very lowest levels of culture, but that, arising in the higher savagery, it develops itself in the barbaric stage, and thenceforth continues or dwindles in survival.

Of the murderous practices to which this opinion leads, remarkably distinct accounts may be cited from among tribes of the Indian Archipelago. The following account is given of the funerals of great men among the savage Kayans of Borneo: "Slaves are killed in order that they may follow the deceased and attend upon him. Before they are killed the relations who surround them enjoin them to take great care of their master when they join him, to watch and shampoo him when he is indisposed, to be always near him, and to obey all his behests. The female relatives of the deceased then take a spear and slightly wound the victims, after which the males spear them to death." Again, the opinion of the Idaan is "that all whom they kill in this world shall attend them as slaves after death. This notion of future interest in the destruction of the

human species is a great impediment to an intercourse with them, as murder goes further than present advantage or resentment. From the same principle they will purchase a slave, guilty of any capital crime, at fourfold his value, that they may be his executioners." With the same idea is connected the ferocious custom of "head-hunting," so prevalent among the Dayaks before Rajah Brooke's time. They considered that the owner of every human head they could procure would serve them in the next world, where, indeed, a man's rank would be according to his number of heads in this. They would continue the mourning for a dead man till a head was brought in, to provide him with a slave to accompany him to the "habitation of souls"; a father who lost his child would go out and kill the first man he met, as a funeral ceremony; a young man might not marry till he had procured a head, and some tribes would bury with a dead man the first head he had taken, together with spears, cloth, rice, and betel. Waylaying and murdering men for their heads became, in fact, the Dayaks' national sport, and they remarked "the white men read books, we hunt heads instead." Of such rites in the Pacific Islands, the most hideously purposeful accounts reach us from the Fiji group. Till lately, a main part of the ceremony of a great man's funeral was the strangling of wives, friends, and slaves, for the distinct purpose of attending him into the

world of spirits. Ordinarily, the first victim was the wife of the deceased, and more than one if he had several, and their corpses, oiled as for a feast, clothed with new fringed girdle, with heads dressed and ornamented, and vermilion and turmeric powder spread on their faces and bosoms, were laid by the side of the dead warrior. Associates and inferior attendants were likewise slain, and these bodies were spoken of as "grass for bedding the grave." When Ra Mbithi, the pride of Somosomo, was lost at sea, seventeen of his wives were killed; and after the news of the massacre of the Namena people, in 1839, eighty women were strangled to accompany the spirits of their murdered husbands. Such sacrifices took place under the same pressure of public opinion which kept up the widow-burning in modern India. The Fijian widow was worked upon by her relatives with all the pressure of persuasion and of menace; she understood well that life to her henceforth would mean a wretched existence of neglect, disgrace, and destitution; and tyrannous custom, as hard to struggle against in the savage as in the civilised world, drove her to the grave. Thus, far from resisting, she became importunate for death and the new life to come, and till public opinion reached a more enlightened state, the missionaries often used their influence in vain to save from the strangling cord some wife whom they could have rescued, but who herself refused to live. So repugnant to the native mind was

the idea of a chieftain going unattended into the other world, that the missionaries' prohibition of the cherished custom was one reason of their dislike to Christianity. Many of the nominal Christians, when once a chief of theirs was shot from an ambush, esteemed it most fortunate that a stray shot at the same time killed a young man at a distance from him, and thus provided a companion for the spirit of the slain chief.

In now passing from the consideration of the souls of men to that of the souls of the lower animals, we have first to inform ourselves as to the savage man's idea, which is very different from the civilised man's, of the nature of these lower animals. A remarkable group of observances customary among rude tribes will bring this distinction sharply into view. Savages talk quite seriouly to beasts alive or dead as they would to men alive or dead, offer them homage, ask pardon when it is their painful duty to hunt and kill them. A North American Indian will reason with a horse as if rational. Some will spare the rattlesnake, fearing the vengeance of its spirit if slain; others will salute the creature reverently, bid it welcome as a friend from the land of spirits, sprinkle a pinch of tobacco on its head for an offering, catch it by the tail and dispatch it with extreme dexterity, and carry off its skin as a trophy. If an Indian is attacked and torn by a bear, it is that the beast fell upon him

intentionally in anger, perhaps to revenge the hurt done to another bear. When a bear is killed, they will beg pardon of him, or even make him condone the offence by smoking the peace-pipe with his murderers, who put the pipe in his mouth and blow down it, begging his spirit not to take revenge.

So in Africa, the Kafirs will hunt the elephant, begging him not to tread on them and kill them, and when he is dead they will assure him that they did not kill him on purpose, and they will bury his trunk, for the elephant is a mighty chief, and his trunk is his hand that he may hurt withal. The Congo people will even avenge such a murder by a pretended attack on the hunters who did the deed. Such customs are common among the lower Asiatic tribes. The Stiens of Kambodia ask pardon of the beast they have killed; the Ainos of Yesso kill the bear, offer obeisance and salutation to him, and cut up his carcase. The Koriaks, if they have slain a bear or wolf, will flay him, dress one of their people in the skin, and dance round him, chanting excuses that they did not do it, and especially laying the blame on a Russian. But if it is a fox, they take his skin, wrap his dead body in hay, and sneering tell him to go to his own people and say what famous hospitality he has had and how they gave him a new coat instead of his old one. The Samoyeds excuse

themselves to the slain bear, telling him it was the Russians who did it, and that a Russian knife will cut him up. The Goldi will set up the slain bear, call him "my lord" and do ironical homage to him, or taking him alive will fatten him in a cage, call him "son" and "brother," and kill and eat him as a sacrifice at a solemn festival. In Borneo, the Dayaks, when they have caught an alligator with a baited hook and rope, address him with respect and soothing till they have his legs fast, and then mocking call him "rajah" and "grandfather". Thus when the savage gets over his fears, he still keeps up in ironical merriment the reverence which had its origin in trembling sincerity. Even now the Norse hunter will say with horror of a bear that will attack man, that he can be "no Christian bear".

The sense of an absolute psychical distinction between man and beast, so prevalent in the civilised world, is hardly to be found among the lower races. Men to whom the cries of beasts and birds seem like human language, and their actions guided as it were by human thought, logically enough allow the existence of souls to beasts, birds, and reptiles, as to men. The lower psychology cannot but recognise in beasts the very characteristic which it attributes to the human soul, namely, the phenomena of life and death, will and judgment, and the phantom seen in vision or in dream. As for believers, savage or

civilised, in the great doctrine of metempsychosis, these not only consider that an animal may have a soul, but that this soul may have inhabited a human being, and thus the creature may be in fact their own ancestor or once familiar friend. A line of facts, arranged as waymarks along the course of civilisation, will serve to indicate the history of opinion from savagery onward, as to the souls of animals during life and after death. North American Indians held every animal to have its spirit, and these spirits their future life; the soul of the Canadian dog went to serve his master in the other world; among the Sioux, the prerogative of having four souls was not confined to man, but belonged also to the bear, the most human of animals. The Greenlanders considered that a sick human soul might be replaced by the sorcerer with a fresh healthy soul of a hare, reindeer, or a young child. Maori tale-tellers have heard of the road by which the spirits of dogs descend to Reinga, the Hades of the departed; the Hovas of Madagascar know that the ghosts of beasts and men, dwelling in a great mountain in the south called Ambondromble, come out occasionally to walk among the tombs or execution places of criminals. The Kukis of Assam think that the ghost of every animal a Kuki kills in the chase or for the feast will belong to him in the next life, even as the enemy he slays in the field will then become his slave. The Karens apply the doctrine of the spirit or personal life-phantom, which is apt

to wander from the body and thus suffer injury, equally to men and to animals. The Zulus say the cattle they kill come to life again, and become the property of the dwellers in the world beneath. The Siamese butcher, when in defiance of the very principles of his Buddhism he slaughters an ox, before he kills the creature has at least the grace to beseech its spirit to seek a happier abode. In connection with such transmigration, Pythagorean and Platonic philosophy gives to the lower animals undying souls, while other classic opinion may recognise in beasts only an inferior order of soul, only the "anima" but not the human "animus" besides.

Through the middle ages, controversy as to the psychology of brutes has lasted on into our own times, ranging between two extremes; on the one, the theory of Descartes which reduced animals to mere machines, on the other what Mr. Alger defines as "the faith that animals have immaterial and deathless souls." Among modern speculations may be instanced that of Wesley, who thought that in the next life animals will be raised even above their bodily and mental state at the creation, "the horridness of their appearance will be exchanged for their primeval beauty, and it even may be that they will be made what men are now, creatures capable of religion." Adam Clarke's argument for the future life of animals rests on abstract justice: whereas they did not sin, but

yet are involved in the sufferings of sinful man, and cannot have in the present state the happiness designed for them, it is reasonable that they must have it in another. Although, however, the primitive belief in the souls of animals still survives to some extent in serious philosophy, it is obvious that the tendency of educated opinion on the question whether brutes have soul, as distinguished from life and mind, has for ages been in a negative and skeptical direction. The doctrine has fallen from its once high estate. It belonged originally to real, though rude science. It has now sunk to become a favourite topic in the mild speculative talk which still does duty so largely as intellectual conversation, and even then its propounders defend it with a lurking consciousness of its being after all a piece of sentimental nonsense.

Animals being thus considered in the primitive psychology to have souls like human beings, it follows as the simplest matter of course that tribes who kill wives and slaves, to dispatch their souls on errands of duty with their departed lords, may also kill animals in order that their spirits may do such service as is proper to them. The Pawnee warrior's horse is slain on his grave to be ready for him to mount again, and the Comanche's best horses are buried with his favourite weapons and his pipe, all alike to be used in the distant happy hunting-grounds. In South America not only do such rites occur, but they reach a

practically disastrous extreme. Patagonian tribes believe in another life, where they are to enjoy perfect happiness, therefore they bury with the deceased his arms and ornaments, and even kill on his tomb all the animals which belonged to him, that he may find them in the abode of bliss; and this opposes an insurmountable barrier to all civilisation, by preventing them from accumulating property and fixing their habitations. Certain Esquimaux would lay a dog's head in a child's grave, that the soul of the dog, who ever finds his home, may guide the helpless infant to the land of souls. In the distant region of the Aztecs, one of the principal ceremonies was to slaughter a native dog; it was burnt or buried with the corpse, with a cotton thread fastened to its neck, and its office was to convey the deceased across the deep waters of Chiuhnahuapan, on the way to the Land of the Dead. The dead Buraet's favourite horse, led saddled to the grave, killed, and flung in, may serve for a Tartar example. In Tonquin, even wild animals have been customarily drowned at funeral ceremonies of princes, to be at the service of the departed in the next world. Among Semitic tribes, an instance of the custom may be found in the Arab sacrifice of a camel on the grave, for the dead man's spirit to ride upon. Among the nations of the Aryan race in Europe, the prevalence of such rites is deep, wide, and full of purpose. Thus,

warriors were provided in death with horses and housings, with hounds and falcons. Customs thus described in chronicle and legend, are vouched for in our own time by the opening of old barbaric burial-places. How clear a relic of savage meaning lies here may be judged from a Livonian account as late as the fourteenth century, which relates how men and women, slaves, sheep, and oxen, with other things, were burnt with the dead, who, it was believed, would reach some region of the living, and find there, with the multitude of cattle and slaves, a country of life and happiness. As usual, these rites may be traced onward in survival. The Mongols, who formerly slaughtered camels and horses at their owner's burial, have been induced to replace the actual sacrifice by a gift of the cattle to the Lamas. The Hindus offer a cow to the Brahmins, in order to secure their passage across the Vaitarani, the river of death, and will often die grasping the cow's tail as if to swim across in herdsman's fashion, holding on to the cow. It is mentioned as a belief in Northern Europe that he who has given a cow to the poor will find a cow to take him over the bridge of the dead, and a custom of leading a cow in the funeral procession is said to have been kept up to modern times. All these rites probably belong together as connected with ancient funeral sacrifice, and the survival of the custom of sacrificing the warrior's horse at his

tomb is yet more striking. Saint-Foix long ago put the French evidence very forcibly. Mentioning the horse led at the funeral of Charles VI, with the four valets de pied in black, and bare-headed, holding the corners of its caparison, he recalls the horses and servants killed and buried with pre-Christian kings. And that his readers may not think this an extraordinary idea, he brings forward the records of property and horses being presented at the offertory in Paris, 1329, of Edward III, presenting horses at King John's funeral in London, and of the funeral service for Bertrand Duguesclin, at St. Denis, in 1389, when horses were offered, the Bishop of Auxerre laid his hand on their heads, and they were afterwards compounded for. Germany retained the actual sacrifice within the memory of living men. A cavalry general called Frederick Kasimir was buried at Treves in 1781 according to the forms of the Teutonic Order; his horse was led in the procession, and the coffin having been lowered into the grave, the horse was killed and thrown in upon it. This was perhaps, the last occasion when such a sacrifice was consummated in solemn form in Europe. But that pathetic incident of a soldier's funeral, the leading of the saddled and bridled charger in the mournful procession, keeps up to this day a lingering reminiscence of the grim religious rite now passed away.

Plants, partaking with animals the phenomena of life and death, health and sickness, not unnaturally have some kind of soul ascribed to them. In fact, the notion of a vegetable soul, common to plants and to the higher organisms possessing an animal soul in addition, was familiar to mediaeval philosophy, and is not yet forgotten by naturalists. But in the lower ranges of culture, at least within one wide district of the world, the souls of plants are much more fully identified with the souls of animals. The Society Islanders seem to have attributed surviving soul or spirit, not to men only, but to animals and plants. The Dayaks of Borneo not only consider men and animals to have a spirit or living principle, whose departure from the body causes sickness and eventually death, but they also give to the rice its "samangat padi," or "spirit of the paddy," and they hold feasts to retain this soul securely, lest the crop should decay. The Karens say that plants as well as men and animals have their "la," and the spirit of sickly rice is here also called back like a human spirit considered to have left the body. Their formulas for the purpose have even been written down, and this is part of one: "O come, rice kelah come. Come to the field. Come to the rice. . . . Come from the West. Come from the East. From the throat of the bird, from the maw of the ape, from the throat of the elephant. . . . From all granaries, come.

O rice kelah, come to the rice." There is reason to think that the doctrines of the spirits of plants lay deep in the intellectual history of South East Asia, but was in great measure superseded under Buddhist influence. The Buddhist books show that in the early days of their religion it was matter of controversy whether trees had souls, and therefore whether they might lawfully be injured. Orthodox Buddhism decided against the tree-souls, and consequently against the scruple to harm them, declaring trees to have no mind nor sentient principle, though admitting that certain devas or spirits do reside in the body of trees, and speak from within them. Buddhists also relate that a heterodox sect kept up the early doctrine of the actual animate life of trees, in connection with which may be remembered Marco Polo's somewhat doubtful statement as to certain austere Indians objecting to green herbs for such a reason, and some other passages from later writers. Generally speaking, the subject of the spirits of plants is an obscure one, whether from the lower races not having definite opinions, or from our not finding it easy to trace them. The evidence from funeral sacrifices, so valuable as to most departments of early psychology, fails us here, from plants not being thought suitable to send for the service of the dead. Yet, there are two topics which bear closely on the matter. On the one hand, the doctrine of transmigration widely

and clearly recognises the idea of trees or smaller plants being animated by human souls; on the other, the belief in tree-spirits and the practice of tree worship involve notions more or less closely coinciding with that of tree-souls, as when the classic hamadryad dies with her tree, or when the Talein of South East Asia, considering every tree to have a demon or spirit, offers prayers before he cuts one down.

Thus far the details of the lower animistic philosophy are not very unfamiliar to modern students. The primitive view of the souls of men and beasts as asserted or acted on in the lower and middle levels of culture, so far belongs to current civilised thought, that those who hold the doctrine to be false, and the practices based upon it futile, can nevertheless understand and sympathise with the lower nations to whom they are matters of the most sober and serious conviction. Nor is even the notion of a separable spirit or soul as the cause of life in plants too incongruous with ordinary ideas to be readily appreciable. But theory of souls in the lower culture stretches beyond this limit, to take in a conception much stranger to modern thought. Certain high savage races distinctly hold, and a large proportion of other savage and barbarian races make a more or less close approach to, a theory of separable and surviving souls or spirits belonging to stocks

and stones, weapons, boats, food, clothes, ornaments, and other objects which to us are not merely soulless but lifeless.

Yet, strange as such a notion may seem to us at first if we place ourselves by an effort in the intellectual position of an uncultured tribe, and examine the theory of object souls, from their point of view, we shall hardly pronounce it irrational. In discussing the origin of myth, some account has been already given of the primitive stage of thought in which personality and life are ascribed not to men and beasts only, but to things. It has been shown how what we call inanimate objects—rivers, stones, trees, weapons, and so forth—are treated as living intelligent beings, talked to, propitiated, punished for the harm they do. Hume, whose "Natural History of Religion" is perhaps more than any other work the source of modern opinions as to the development of religion, comments on the influence of this personifying stage of thought. "There is an universal tendency among mankind to conceive all beings like themselves, and to transfer to every object those qualities with which they are familiarly acquainted, and of which they are intimately conscious. The unknown causes, which continually employ their thought, appearing always in the same aspect, are all apprehended to be of the same kind or species. Nor is it long before we ascribe to them thought and reason, and

passion, and sometimes even the limbs and figures of men, in order to bring them nearer to a resemblance with ourselves." August Comte has ventured to bring such a state of thought under terms of strict definition in his conception of the primary mental condition of mankind—a state of "pure fetishism, constantly characterised by the free and direct exercise of our primitive tendency to conceive all external bodies soever, natural or artificial, as animated by a life essentially analogous to our own, with mere differences of intensity." Our comprehension of the lower stages of mental culture depends much on the thoroughness with which we can appreciate this primitive, childlike conception, and in this our best guide may be the memory of our own childish days. He who recollects when there was still personality to him in posts and sticks, chairs and toys, may well understand how the infant philosophy of mankind could extend the notion of vitality to what modern science only recognises as lifeless things; thus one main part of the lower animistic doctrine as to souls of objects is accounted for. The doctrine requires for its full conception of a soul not only life, but also a phantom or apparitional spirit; this development, however, follows without difficulty, for the evidence of dreams and visions applies to the spirits of objects in much the same manner as to human ghosts. Everyone who has seen visions while light-headed in fever, every-

one who has ever dreamt a dream, has seen the phantoms of objects as well as of persons. How then can we charge the savage with far-fetched absurdity for taking into his philosophy and religion an opinion which rests on the very evidence of his senses? The notion is implicitly recognised in his accounts of ghosts, which do not come naked, but clothed, and even armed; of course there must be spirits of garments and weapons, seeing that the spirits of men come bearing them. It will indeed place savage philosophy in no unfavourable light, if we compare this extreme animistic development of it with the popular opinion still surviving in civilised countries, as to ghosts and the nature of the human soul as connected with them. When the ghost of Hamlet's father appeared armed cap-a-pie,

"Such was the very armour he had on,
When he the ambitious Norway combated."

And thus it is a habitual feature of the ghost-stories of the civilised, as of the savage world, that the ghost comes dressed, and even dressed in well-known clothing worn in life. Hearing as well as sight testifies to the phantoms of objects: the clanking of ghostly chains and the rustling of ghostly dresses are described in the literature of apparitions. Now by the savage theory, according to which the ghost and his clothes are like imaginary and subjective, the facts of apparitions are rationally met. But the modern vulgar who

ignore or repudiate the notion of ghosts of things, while retaining the notion of ghosts of persons, have fallen into a hybrid state of opinion which has neither the logic of the savage nor of the civilised philosopher.

It remains to sum up in a few words the doctrine of souls, in the various phases it has assumed from first to last among mankind. In the attempt to trace its main course through the successive grades of man's intellectual history, the evidence seems to accord best with a theory of its development, somewhat to the following effect. At the lowest levels of culture of which we have clear knowledge, the notion of a ghost-soul animating man while in the body, is found deeply ingrained. There is no reason to think that this belief was learnt by savage tribes from contact with higher races, nor that it is a relic of higher culture from which the savage tribes have degenerated; for what is here treated as the primitive animistic doctrine is thoroughly at home among savages, who appear to hold it on the very evidence of their senses, interpreted on the biological principle which seems to them most reasonable. We may now and then hear the savage doctrines and practices concerning souls claimed as relics of a high religious culture pervading the primeval race of man. They are said to be traces of remote ancestral religion, kept up in scanty and perverted memory by tribes

degraded from a nobler state. It is easy to see that such an explanation of some few facts, sundered from their connection with the general array, may seem plausible to certain minds. But a large view of the subject can hardly leave such argument in possession. The animism of savages stands for and by itself; it explains its own origin. The animism of civilised men, while more appropriate to advanced knowledge, is in great measure only explicable as a developed product of the older and ruder system. It is the doctrines and rites of the lower races which are, according to their philosophy, results of point-blank natural evidence and acts of straightforward practical purpose. It is the doctrines and rites of the higher races which show survival of the old in the midst of the new, modification of the old to bring it into conformity with the new, abandonment of the old because it is no longer compatible with the new. Let us see at a glance in what general relation the doctrine of souls among savage tribes stands to the doctrine of souls among barbaric and cultured nations. Among races within the limits of savagery, the general doctrine of souls is found worked out with remarkable breadth and consistency. The souls of animals are recognised by a natural extension from the theory of human souls; the souls of trees and plants follow in some vague partial way; and the souls of inanimate objects expand the general category to its extremest boundary.

Thenceforth, as we explore human thought onward from savage into barbarian and civilised life, we find a state of theory more conformed to positive science, but in itself less complete and consistent. Far on into civilisation, men still act as though in some half-meant way they believed in souls or ghosts of objects, while nevertheless their knowledge of physical science is beyond so crude a philosophy. As to the doctrine of souls of plants fragmentary evidence of the history of its breaking down in Asia has reached us. In our own day and country, the notion of souls of beasts is to be seen dying out. Animism, indeed, seems to be drawing in its outposts, and concentrating itself on its first and main position, the doctrine of the human soul. This doctrine has undergone extreme modification in the course of culture. It has outlived the almost total loss of one great argument attached to it—the objective reality of apparitional souls or ghosts seen in dreams and visions. The soul has given up its ethereal substance, and become an immaterial entity, "the shadow of a shade." Its theory is becoming separated from the investigations of biology and mental science, which now discuss the phenomena of life and thought, the sense and the intellect, the emotions and the will on a groundwork of pure experience. There has arisen an intellectual product whose very existence is of the deepest significance, a "psychology" which has no longer any-

thing to do with "soul." The soul's place in modern thought is in the metaphysics of religion, and its especial office there is that of furnishing an intellectual side to the religious doctrine of the future life. Such are the alterations which have differenced the fundamental animistic belief in its course through successive periods of the world's culture. Yet it is evidence that, notwithstanding all this profound change, the conception of the human soul is, as to its most essential nature, continuous from the philosophy of the savage thinker to that of the modern professor of theology. Its definition has remained from the first that of an animating, separable, surviving entity, the vehicle of individual personal existence. The theory of the soul is one principal part of a system of religious philosophy, which unites, in an unbroken line of mental connection, the savage fetish-worshiper and the civilised Christian. The divisions which have separated the great religions of the world into intolerant and hostile sects are for the most part superficial in comparison with the deepest of all religious schisms, that which divides Animism from Materialism.

CHAPTER III

THE ORIGIN OF LIFE

BY J. B. S. HALDANE

UNTIL about 150 years ago, it was generally believed that living beings were constantly arising out of dead matter. Maggots were supposed to be generated spontaneously in decaying meat. In 1668, Redi showed that this did not happen, provided insects were carefully excluded. And in 1860 Pasteur extended the proof to the bacteria which he had shown were the cause of putrefaction. It seems fairly clear that all the living beings known to us originate from other living beings. At the same time, Darwin gave a new emotional interest to the problem. It had appeared unimportant that a few worms should originate from mud. But if man was descended from worms, such spontaneous generation acquired a new significance. The origin of life on the earth would have been as casual an affair as the evolution of monkeys into man. Even if the latter stages of man's history were due to natural causes, pride clung to a super-natural, or at least surprising, mode of origin for

his ultimate ancestors. So it was with a sigh of relief that a good many men, whom Darwin's arguments had convinced, accepted the conclusion of Pasteur that life can originate only from life. It was possible either to suppose that life had been supernaturally created on earth some millions of years ago, or that it had been brought to earth by a meteorite or by micro-organisms floating through inter-stellar space. But a large number, perhaps the majority, of biologists, believed, in spite of Pasteur, that at some time in the remote past, life had originated on earth from dead matter as the result of natural processes.

The more ardent materialists tried to fill in the details of this process, but without complete success. Oddly enough, the few scientific men who professed idealism agreed with them. For each one can find evidences of mind (in religious terminology, the finger of God) in the most ordinary events, even those which go on in the chemical laboratory, one can without much difficulty believe in the origin of life from such processes. Pasteur's work, therefore, appealed most strongly to those who desired to stress the contrast between mind and matter. For a variety of obscure historical reasons, the Christian Churches have taken this latter point of view. But it should never be forgotten that the early Christians held many views which are now regarded as materialistic. They believed in the resurrection of

the body, not the immortality of the soul. Saint Paul seems to have attributed consciousness and will to the body. He used a phrase translated in the Revised Version (of the Holy Bible) as "the mind of the flesh," and credited the flesh with a capacity for hatred, wrath and other mental functions. Many modern physiologists hold similar beliefs. But, perhaps unfortunately for Christianity, the Church was captured by a group of very inferior Greek philosophers in the third and fourth century A. D. Since that date, views as to the relation between mind and body, which Saint Paul at least did not hold, have been regarded as part of Christianity, and have retarded the process of science.

It is hard to believe that any lapse of time will dim the glory of Pasteur's positive achievements. He published singularly few experimental results. It has even been suggesed by a cynic that his entire work would not gain a doctorate of philosophy to-day! But every experiment was final. I have never heard of any one who has repeated any experiment of Pasteur's with a result different from that of the master. His deductions from these experiments were sometimes too sweeping. It is perhaps not quite irrelevant that he worked in his latter years with half a brain. His right cerebral hemisphere had been extensively wrecked by the bursting of an artery when he was only 45 years old; and the united brain

power of the micro-biologists who had succeeded him has barely compensated for that accident. Even during his life time, some of the conclusions which he had drawn from his experimental work were disproved. He had said that alcoholic fermentation was impossible without life. Buchner obtained it with a cell-free and dead extract of yeast. And since his death, the gap between life and matter has been greatly narrowed.

When Darwin deduced the animal origin of man, a search began for a "missing link" between ourselves and the apes. (When Dubois found the bones of Pithecanthropus, some comparative anatomists at once proclaimed that they were of animal origin, while others were equally convinced that they were parts of human skeleton.) It is now generally recognised that either party was right, according to the definition of humanity adopted. (Pithecanthropus was a creature which might legitimately be described either as a man or an ape, and its existence showed that the distinction between the two was not absolute.)

Now the recent study of ultra-microscopic beings has brought up at least one parallel case, that of the bacteriophage, discovered by d'Herelle, who had been to some extent anticipated by Twort. This is the cause of a disease, or, at any rate, abnormality of bacteria. Before the size of the atom was known, there was no reason to doubt that,

Big flees have little flees
Upon their backs to bite 'em;
The little ones have lesser ones,
And so on ad infinitum.

But we know now that this is impossible. Roughly speaking, from the point of view of size, the bacillus is the flee's flee, the bacteriophage the bacillus ' flee; but the bacteriophage's flee would be of the dimensions of an atom, and atoms do not behave like flees. In other words, there are only about as many atoms in a cell as cells in a man. This link between living and dead matter is, therefore, somewhere between a cell and an atom.

D'Herelle found that certain cultures of bacteria began to swell up and burst until all had disappeared. If such cultures were passed through a filter fine enough to keep out all bacteria, the filtrate could infect fresh bacteria, and so on indefinitely. Though the infective agents cannot be seen with a microscope, they can be counted as follows. If an active filtrate containing bacteriophage be poured over a colony of bacteria on a jelly, the bacteria will all, or almost all, disappear. If it be diluted many thousand times, a few islands of living bacteria survive for some time. If it be diluted about ten million-fold, the bacteria are destroyed round only a few isolated spots, each representing a single particle of the bacteriophage.

Since the bacteriophage multiplies, d'Herelle believes it to be a living organism. Bordet and others have taken an opposite view. It will survive heating and other insults which kill the large majority of organisms, and will multiply only in presence of living bacteria, though it can break up dead ones. Except perhaps in the presence of bacteria, it does not use oxygen or display any other signs of life. Bordet and his school, therefore, regard it as a ferment which breaks up bacteria as our own digestive ferments break up our food, at the same time inducing the disintegrating bacteria to produce more of the same ferment. This is not as fantastic as it sounds, for most cells, while dying, liberate or activate ferments which digest themselves. But these ferments are certainly feeble when compared with the bacteriophage.

Clearly we are in doubt as to the proper criterion of life. D'Herelle says that the bacteriophage is alive, because, like the flee or the tiger, it can multiply indefinitely at the cost of living beings. His opponents say that it can multiply only as long as its food is alive, whereas the tiger certainly, and the flee probably, can live on dead products of life. They suggest that the bacteriophage is like a book or a work of art, which is constantly being copied by living beings, and, is therefore only metaphorically alive, its real life being in its copiers.

The American geneticist Muller has, however, suggested an intermediate view. He compares the bacteriophage to a gene — that is to say, one of the units concerned in heredity. A fully coloured and a spotted dog differ because the latter has in each of its cell one or two of a certain gene, which we know is too small to see with a microscope. Before a cell of a dog divides this gene, this gene divides also, so that each of the daughter cells has one, two, or none according with the number in the parent cell. The ordinary spotted dog is healthy, but a gene common among German dogs causes a roan colour when one is present, while two make the dog nearly white, wall-eyed and generally deaf, blind or both. Most of such dogs die young, and the analogy to the bacteriophage is fairly close. The main difference between such a lethal gene, of which many are known, and the bacteriophage, is that the one is only known inside the cell, the other outside. In the present state of our ignorance, we may regard the gene either as a tiny organism which can divide in the environment provided by the rest of the cell; or as a bit of machinery which the "living" cell copies at each division. The truth is probably somewhere in between these two hypotheses.

Unless a living creature is a piece of dead matter plus a soul, (a view which finds little support in modern biology), something of the

following kind must be true. A simple organism must consist of parts, each of which can multiply only in presence of all, or almost all, of the others. Among these parts are genes, and the bacteriophage is such a part which has got loose. This hypothesis becomes more plausible if we believe in the work of Hauduroy, who finds that the ultra-microscopic particles into which the bacteria have been broken up, and which pass through filters that can stop the bacteria, occasionally grow up again into bacteria after a lapse of several months. He brings evidence to show that such fragments of bacteria may cause disease, and d'Herelle and Payne claim to have found the ultra-microscopic form of a common staphylococcus, along with bacteriophage, in cancers, and suspect that this combination may be the cause of that disease.

On this view, the bacteriophage is a cog, as it were, in the wheel of a life-cycle of many bacteria. The same bacteriophage can act on different species, and is thus, so to say, a spare part which can be fitted into a number of different machines, just as a human diabetic can remain in health when provided with insulin manufactured by a pig. A great many kinds of molecule have been got from cells, and many of them are very different when removed from it. One can separate from yeast one of the many tools which it uses in alcoholic fermentation, an enzyme called

invertase, and this will break up six times its weight of cane sugar per second for an indefinite time without wearing out. As it does not form alcohol from the sugar, but only a sticky mixture of other sugars, its use is permitted in the United States in the manufacture of confectionery and cake-icing. But such fragments do not reproduce themselves, though they take part in the assimilation of food by the living cell. No one supposes that they are alive. The bacteriophage is a step beyond the enzyme on the road to life, but it is perhaps an exaggeration to call it fully alive. At about the same stage, on the road are the viruses which cause such diseases as small-pox, herpes, and hydrophobia. They can multiply only in living tissue, and pass through filters which stop bacteria.

With these facts in mind, we may legitimately speculate on the origin of life on this planet. With a few thousand years from its origin, it probably cooled down so as to develop a fairly permanent solid crust. For a long time, however, this crust must have been above the boiling point of water, which condensed only gradually. The primitive atmosphere probably contained little or no oxygen, for our present supply of that gas is only about enough to burn all the coal and other organic remains found below and on the earth's surface. On the other hand, almost all the carbon of these organic substances, and much of the carbon now combined in chalk, limestone and dolomite, were

in the atmosphere as carbon dioxide. Probably, a good deal of the nitrogen now in the air was combined with metals as nitrite in the earth's crust, so that ammonia was constantly being formed by the action of water. The sun was perhaps slightly brighter than it is now, and as there was no oxygen in the atmosphere, the chemically active ultra-violet rays from the sun were not, as they now are, mainly stopped by ozone in the upper atmosphere, and by oxygen itself lower down. They penetrated to the surface of the land and sea, or at least to the clouds.

Now, when ultra-violet light acts on a mixture of water, carbon dioxide and ammonia, a vast variety of organic substances are made, including sugar and apparently some of the materials from which proteins are built up. This fact has been demonstrated in the laboratory by Baly of Liverpool and his colleagues. In this present world, such substances, if left about, decay,—that is to say, they are destroyed by micro-organisms. But before the origin of life, they must have accumulated till the primitive oceans reached the consistency of hot dilute soup. To-day an organism must trust to luck, skill or strength to obtain its food. The first ‚precursors of life found food available in considerable quantities, and had no competitors in the struggle for existence. As the primitive atmosphere contained little or no oxygen, they must have obtained the energy which

they needed for growth by some other process than oxidation—in fact, by fermentation. For, as Pasteur put it, fermentation is life without oxygen. If this was so, we should expect that high organisms like ourselves would start life as anaerobic beings, just as we start as single cells. This is the case. Embryo chicks, for the first two or three days after fertilisation use very little oxygen, but obtain the energy which they need for growth by fermenting sugar into lactic acid, like the bacteria which turns milk sour. So do various embryo mammals, and in all probability you and I lived mainly by fermentation during the first week of our pre-natal life. The cancer cell behaves in the same way. Warburg has shown that with its embryonic habit of unrestricted growth, there goes an embryonic habit of fermentation.

The first living or half-living beings were probably large molecules synthesised under the influence of the sun's radiation, and only capable of reproduction in the particularly favourable medium in which they originated. Each presumably required a variety of highly specialised molecules before it could reproduce itself, and it depended on chance for a supply of them. This is the case to-day with most viruses, including the bactariophage, which can grow only in presence of the complicated assortment of molecules found in a living cell.

The unicellar organisms, including bacteria which were the simplest living things known a generation ago, are far more complicated. They are organisms—that is to say, systems whose parts co operate. Each part is specialised to a particular chemical function, and prepares chemical molecules suitable for the growth of the other parts. In consequence, the cell as a whole can usually subsist on a few types of molecule, which are transformed within it into the more complex substances needed for the growth of the parts.

The cell consists of numerous half-living chemical molecules, suspended in water and enclosed in an oily film. When the whole sea was a vast chemical laboratory, the conditions for the formation of such films must have been relatively favourable; but for all that, life may have remained in the virus stage for many millions of years before a suitable assemblage of elementary units was brought together in the first cell. There must have been many failures, but the first successful cell had plenty of food, and an immense advantage over its competitors.

It is probable that all organisms now alive are descended from one ancestor, for the following reason. Most of our structural molecules are asymmetrical, as shown by the fact that they rotate the plane of polarised light, and often form asymmetrical crystals. But of the two possible types of any such molecule, related to one another like a

right and left boot, only one is found throughout living nature. The apparent exceptions to this rule are all small molecules which are not used in the building of the large structures which display the phenomena of life. There is nothing, so far as we can see, in the nature of things to prevent the existence of looking-glass organisms built from molecules which are, so to say, the mirror images of those in our own bodies. Many of the requisite molecules have already been made in the laboratory. If life had originated independently on several occasions, such organisms would probably exist. As they do not, this event probably occurred only once, or, more probably, the descendents of the first living organism rapidly evolved far enough to overwhelm any latter competitors when these arrived on the scene.

As the primitive organisms used up the foodstuffs available in the sea, some of them began to perform in their own bodies the synthesis formerly performed at haphazard by the sun-light, thus ensuring a liberal supply of food. The first plants thus came into existence, living near the surface of the ocean, and making food with the aid of sun-light as do their descendants to-day. It is thought by many biologists that we animals are descended from them. Among the molecule in our own bodies, are a number whose structure resembles that of chlorophyll, the green pigment with which the plants have harnessed the

sun-light to their needs. We use them for other purposes than the plants—for example, for carrying oxygen—and we do not, of course, know whether they are, so to speak, descendants of chlorophyll or merely cousins. But since the oxygen liberated by the first plants must have killed off most of the other organisms, the former view is the more plausible.

The above conclusions are speculative. They will remain so until living creatures have been synthesised in the bio-chemical laboratory. We are a long way from that goal. It was only this year that Pictet, for the first time, made cane-sugar artificially. It is doubtful whether any enzyme has been obtained quite pure. Nevertheless, I hope to live to see one made artificially. I do not think I shall behold the synthesis of anything so nearly alive as a bacteriophage or a virus, and I do not suppose that a self-contained organism will be made for centuries. Until that is done, the origin of life will remain a subject for speculation. But such speculation is not idle, because it is susceptible of experimental proof or disproof.

Some people will consider it a sufficient refutation of the above theories to say that they are materialistic, and that materialism can be refuted on philosophical grounds. They are no doubt compatible with materialism, but also with other philosophical tenets. The facts are after

all fairly plain. Just as we know of sight only in connection with a particular kind of material system called the eye, so we know only of life in connection with certain arrangements of matter, of which the bio-chemists can give a good, but far from complete, account. The question at issue is: "How did the first such system on this planet originate?" This is an historical problem to which I have given a very tentative answer on the not unreasonable hypothesis that a thousand million years ago, matter obeyed the same laws that it does to-day.

This answer is compatible, for example, with the view that pre-existent mind or spirit can associate itself with certain kinds of matter. If so, we are left with the mystery as to why mind has so marked a preference for a particular type of colloidal organic substances. Personally, I regard all attempts to describe the relation of mind to matter as rather clumsy metaphors[1]. The bio-chemist knows no more, and no less, about this question than anyone else. His ignorance disqualifies him no more than the historian or geologist from attempting to solve an historical problem.

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[1] I think that in view of recent developments in physics and cerebral physiology, this statement is over-emphatic

CHAPTER IV

THE CAUSES OF EVOLUTION

BY J. B. S. HALDANE

THERE is a singularly universal agreement among biologists that Evolution has occurred—that is to say, that the organisms now living are descended from ancestors from whom they differ very considerably. A very few, including a distinguished Jesuit entomologist, try to narrow down its scope, but so far as I know none deny it. To do so, it would be necessary either to affirm that fossils were never alive, but created as such, presumably by the devil as stumbling blocks; or that species were wiped out and their successors created on a slightly fantastic scale. For example, the members of one single genus of sea-urchins would have to have been wiped out and replaced by barely distinguishable successors some dozens of times during the course of the deposition of the English chalk. This is a *reductio ad absurdum* of a view which was tenable when only a few groups of extinct organisms belonging to very different epochs were known. But if evolution is admitted as an historical

fact, it can still be explained in many different ways.

The iguanodon has been replaced by the sheep and cow, the Austrian Empire by the succession States. Some few people will attribute both these events to the direct intervention of the Almighty, few others to the mere interaction of atoms according to the law of physics and chemistry. Most will adopt some intermediate point of view. We have therefore to ask ourselves whether evolution shows signs of intelligent, or even instinctive, guidance; and, if not, whether it can be explained as the outcome of causes which we can see at work around us, and whose action is fairly intelligible.

Popular ideas of evolution are greatly biased by the fact that so much stress is laid on the ancestry of such animals as men, horses and birds, which are, according to human standards of value, superior to their ancestors. We are, therefore, inclined to regard progress as the rule in evolution. Actually it is the exception, and for every case of it there are ten of degeneration. It is impossible to define this latter word accurately, but I shall use it to cover cases where an organ or function has been lost without any obvious corresponding gain, and in particular the assumption of a parasitic or sessile mode of life. To take an obvious example, the birds were almost certainly derived from a single ancestral species which achieved flight. This achievement was followed by a huge

outbreak of variation which has given us the thousands of bird species alive to-day. The essential step was made once, and only once. But the power of flight has been lost on many different occasions—for example, by the ostrich and its allies, the kiwi, the dodo, the great auk, the penguins, the weka, the kakapo (a flightless parrot), and so on. Only the auk and penguins converted their wings into flippers, and may perhaps be absolved from the stigma of degeneracy. Similarly, hundreds of groups have independently taken to parasitism, and in many cases very successfully. On the average, every vertebrate harbours some dozens of parasitic worms, whose remote ancestors were free-living. Blake asks somewhat doubtfully of the tiger:

"Did he who made the land make thee?"

The same question applies with equal force to the tape-worm; and an affirmative answer would clearly postulate a creator whose senses of values could not commend him to the admiration of humanity. But, in spite of this, he might be an intelligent being. Now, it is perhaps the most striking characteristic of an intelligent being that he learns from his mistakes. On the hypothesis of an intelligent guidance of evolution, we should, therefore, expect that, when a certain type of animal had proved itself a failure by becoming extinct, the experiment of making it would not be tried repeatedly. But this has often happened. Both reptiles and mammals have on numerous occasions given rise to giant

clumsy types with from one to six short horns on the head.

Two or three such attempts would have convinced an intelligent demiurge of the futility of the process. That particular type of mistake is almost the rule in vertebrate evolution. Again and again, during the Mesozoic times, great groups of reptiles blossomed out into an inordinate increase of bulk, a wild exuberance of scale and spine, which invariably ended in their extinction. They doubtless enjoyed the satisfaction of squashing a number of our own ancestors and those of the existing reptilian groups, who seem to have been relatively small and meek creatures.

It would seem, then, that there is no need to postulate a directive agency at all resembling our own minds behind evolution. The question now remains whether it can be explained by the so far known laws of nature. In the discussion which follows, we do not, of course, raise the questions as to how life originated, if it ever did; or how far the existence of an intelligible world implies the presence behind it of a mind.

Darwin recognised two causes for evolution—namely, the transmission to the descendants of characters acquired by their ancestors during the course of their lives, and selection. He laid more stress on the latter, and was the first to point out its great importance as a cause of evolution; but, as might be noted by certain anti-Darwinian

writers, were they to read Chapter One of the "Origin of Species," he was far from neglecting the former. Nevertheless, thanks in the main to Weismann, the majority of biologists to-day doubt whether acquired characters are transmitted to the offspring. A vast amount of work has been done to demonstrate, if possible, the effect on an organ of its use or disuse throughout many generations. To take a recent example, Payne bred *Drosophila*, a fly which tends to move towards light, in darkness for 75 generations. At the end of that time, no visible change had occurred in the eyes, and when one thousand such flies were given the opportunity of moving towards a light, no change was found from the normal either in the proportion which moved within a minute, or in the average rate at which they moved. The majority of the experiments on the inheritance of the effects of use and disuse lead to equally negative results. Some of the apparently successful experiments can be explained by selection. For example, wheat taken from Scandinavia to Central Europe and brought back again after some years was found to germinate earlier than its ancestors, and the results were attributed to the effects of earlier germination in a warmer climate. But whereas in Scandinavia the earliest germinating shoots would tend to be nipped by frost, in a warmer climate they would get a start over the latter, and be represented in greater numbers in each successive generation. Hence, if

there was inheritable variation in time of sprouting, selection would occur, and the wheat as a whole would sprout earlier.

Nevertheless, a certain number of cases remain which can hardly be explained away in this manner, nor by the transmission of micro-organisms. Until, however, these are repeated, it will be well to suspend judgment, for in the majority of similar cases brought forward in the past, critical repetition has proved fatal to the conclusions drawn from them.

It must be remembered that, however great the number of experiments that may fail, it is always possible that the effects of use and disuse may be impressed on a species at a rate not susceptible of experimental verification, and yet rapid enough to be of importance in geological time. But the acceptance of this principle, and in particular of the corollary that instinct is in part inherited memory, raises difficulties at least as great as it solves. The most perfect and complex instincts are those of the workers of social insect species, such as bees and termites. Now, a worker-bee is descended entirely from queens and drones. None, or extremely few, of her ancestors have been workers. If, therefore, memory were inherited, the instincts of workers should slowly alter in such a way that their behaviour came to resemble that of sexual forms, and insect societies should be inherently unstable, whereas in fact they appear to date back for at least twenty million years.

The case for natural selection is far stronger. Let us first be clear what is meant by this phrase. Among the offspring of the same parents, variations occur. Some of these are due to accident or disease, and are not transmitted to the next generation; others are inheritable. For example, a single litter of rabbits often contains both coloured and white members. If the whites are bred together, they produce only white young. The coloured ones will produce a majority of themselves and a proportion of-whites. That is to say, both characters are more or less markedly inherited. If now the animals bearing one inheritable character produce, on the whole, more offspring which survives maturity in the next generation, the proportion of the population bearing that character will tend to increase. The phrase, "survival of the fittest" is often rather misleading. It is types, and not individuals, that survive. Of two female deer, the one which habitually abandons its young on the approach of a beast of prey is likely to outlive one which defends them. But, as the latter will leave more offspring, her type survives, even if she loses her life. Hence, in so far as courage and maternal instinct are inherited, they will tend to survive, even if they often lead to the death of the individual. Of course, the fact that nature favours altruistic conduct in certain cases does not mean that biological and moral values are in general the same. As Huxley pointed out long ago, this is by no means the case, and an attempt

to equate moral and biological values is a somewhat crude form of nature worship. But that is not to say that the moralist can neglect biological facts.

The assertion is still sometimes made that no one has ever seen natural selection at work. It is, therefore, perhaps, worth giving in some detail a case recently described by Harrison. About 1800, a large wood in the Cleveland district of Yorkshire, containing pine and birch, was divided into two by a stretch of heath. In 1885, the pines in one division were replaced by birches, while in the other the birches had been almost entirely ousted by pines. In consequence, the moth *Oparabia autumnata*, which inhabits both woods, has been placed in two different environments. In both woods, a light and a dark variety occur. But in the pine wood, over 96 per cent are dark, and in the birch wood only 15 per cent. This is not due to the direct effect of the environment, for the dark pine wood race became no lighter after feeding the caterpillars on birch trees in captivity for three generations, nor can the light form be darkened by placing this variety on pines. The reason for the difference was discovered on collecting the wings of moths found lying about in the pine wood whose owners had been eaten by owls, bats and nightjars. Although there were more than twenty-five living dark moths to each light one, a majority of the wings found were light coloured. The whiter moths which show off against the dark pines are being exterminated, and in a few

more years, natural selection will have done its work, and the pine wood will be inhabited entirely by dark coloured insects. Naturalists are at last beginning to realise the importance of observations of this kind, but they require a combination of field observations with experiment such as is too rarely made.

Now, it is clear that natural selection can act only when it finds variations to act on. It cannot create them, and critics have therefore objected that it cannot really be said to create a new species. It would follow from this line of reasoning that a sculptor who hews a statue from a block of marble has not really made the statue. He has merely knocked away some chips of stone which happened to be round it! Natural selection is creative in the same sense as sculpture. It needs living organisms exhibiting inheritable variations as its raw material. It is not responsible for the existence of organisms, but it remains to be shown that without it organisms would display any tendency to evolve.

Of course, if variation is biased in some one direction, a new problem arises. Variation has only been adequately studied during the last twenty years, and it is necessary to digress on the result of this study. Most inheritable variations which have been investigated are transmitted according to Mendel's laws, except that complete dominance is rather rare. That is to say, they are due to the handing on from parent

to offspring of a unit which we call a gene and which is a material structure located at a definite point in the nucleus of the cell, and dividing at each nuclear division. Characters which appear to vary continuously generally prove on analysis to be due to the interaction of a number of such genes. Now, apart from non-inheritable "fluctuations" due to the environment, there are two distinct types of variations. The first and commonest kind is caused by a mere reshuffling of genes. If we mate a black and white rabbit with a blue angora doe, the offspring, if the parents were pure bred, will be black short-haired rabbits; but among their children, if they are mated together, will appear an outburst of variations. Black, blue, black and white, blue and white rabbits will appear, some of each kind having short hair, some long, due to a reshuffling of the genes contributed by the parents. This sort of variation obeys the laws of chance, and selection will be able to pick out only one most favoured combination, say, short-haired blue rabbits. Almost all variation in the human race is due to this cause.

But there is another and far rarer kind of variation, known as mutation, which consists in the origin [of a new gene. I might breed a million rabbits without getting more than a dozen or so well marked mutations. But the sort of mutations I should expect would be on more or less familiar lines. I should not be surprised if

I got an outbreak of hereditary baldness[1], or came on a new race of rabbits with pink eyes and yellow coat, for these types have arisen in mice; but I should be dumb-founded if one of my rabbits developed hereditary horns, and still more so if feathers were to appear. As a matter of fact, there is a marked parallelism between the new genes which have arisen in nearly related species; and this is intelligible because the structure of their nuclei is similar, and the changes likely to occur in them are therefore also similar. New genes appear to arise as the result of accidents—that is to say, causes which are no doubt determined by the laws of physics, but are no more the concern of the biologist than those governing the fall of a chimney-pot, which has been known to alter the shape of a human head, though not in an inheritable manner. Mutations have been provoked in mice by mild injury of the germplasm with X-rays. The vast majority of mutations are harmful, resulting in an impairment of some structure or function, and are eliminated by natural selection. Others are neutral. In a fly of which some hundreds of millions have been bred in laboratories over four hundred mutations have occurred, some of them on many different occasions. Several have yielded types which are as healthy as the normal under the artificial conditions of the laboratory. And a few, in special circumstances, may be more so. For

[1]This has occurred since the article was written.

example, the recessive white-eyed variety, though considerably less fit than the normal at ordinary temperatures, is less liable to be killed off by heat than the normal. Actually, the fly in question does not live in climates hot enough for this advantage to take effect. It cannot compete with other species which live there. But if it did so, the white-eyed variety would be at an advantage compared with the normal type, at least as regards health. It probably would not be fitter on the whole, as its vision is poor. But some other mutant types probably share its tolerance of heat, and if so, one of them would probably be favoured by natural selection.

It must be remembered that a mutation which in most circumstances would be disadvantageous may be useful in a special environment. Wingless varieties of normally winged insects are common on small oceanic islands, though by no means universal. Mutations causing loss of wings are also common in the laboratory. It is clear that, after an island has been colonised by a winged insect carried by the wind from an adjoining continent, hereditary loss of wings, if not accompanied by degeneration of other structures, will be of value in preventing its successors from being blown out to sea.

It follows, then, that in mutations of this type, we have a means by which sub-species may be formed in nature ; and there is strong evidence that they have been so formed. For example, the three

varieties of the black rat, which have different geographical distributions, differ from one another by single genes quite similar to those which arise by mutation in the laboratory. But there is no evidence at all that mutations are biased in a direction advantageous to the species. The possibilities of mutation do, however, limit the directions in which a species can evolve. Whether it will do so along any of the lines thus laid open to it depends on natural selection. In some cases, as among flowering plants, a good many species seem to be neither better nor worse off than their ancestors and, therefore, to owe their origin primarily to variation. However, a slight change in leaf or flower form is not evolution. To my mind, the most serious argument against selection is that it does not explain the origin of interspecific sterility, except where it is due to external causes such as differences of size or breeding time. It is on these grounds that Batson, a thorough believer in evolution, has criticised natural selection. As I have pointed out elsewhere, a difference of a single gene between two animals may cause the production of an excess of one sex on crossing, as occurs in fowl-pheasant and cow-bison crosses; and several such genes may well cause complete sterility.

Moreover, there is a second type of inheritable variation, leading to a change in the chromozome number, which causes inter-varietal sterility, often without a very marked change in external

characteristics. This is quite common in plants, less so in animals. Although, therefore, the problem of interspecific sterility is serious, we are already well on the way to solving it. By now all the way in some cases.

We must now turn to the paleontological evidence. In a few groups, we can trace the course of evolution in some detail. Thus we know over five thousand species of ammonites, and over two hundred of extinct horses. In the horses, advance took place along several parallel lines, only one of which has left living descendants. In each line, the toes were gradually reduced from three to one, while the molar teeth increased in length and complexity. When, in the past, we find two different species competing in the same area, one is usually farther on the road towards a single toe, the other towards a long molar. We know that these two characters were of value, because we find fossils in which the thin lateral toe reduced to mere vestiges in the modern horse had been broken during the animal's life as shown by subsequent healing. We also find that in the more primitive types the teeth were often worn down to the roots, leading to death from starvation. Hence, for two species to compete equally, their advantages in these two respects must be balanced. For species combining both advantages, as does the modern horse, would oust those possessing one only. Evolution, in the cases where the evidence is most complete, is known to have

been very gradual. Such large changes as those produced by most genes so far studied were rare in evolution. This is natural enough. Geneticists have concentrated their attention on genes which produce striking effects. Now, however, that they are beginning to look for those causing small effects only, and often apparently continuous variation, are finding them.

A more serious objection is that rudimentary characters sometimes appear which can be of no use to their owners, but only become so on further development some thousands of years later. This is almost certainly true, and is at first sight fatal to the selection hypothesis. But it can be met along several lines. A change in one organ, as Darwin pointed out, generally carries with it a change in others. Hence an increase in the complexity of one molar brought about by natural selection may cause the beginning of a new cusp in its neighbour. This cusp will at first be useless, but as it increases, selection will begin to act on it also, so that the process will gather momentum until we arrive at the extremely complex grinders of the elephant or horse. Moreover, we can trace just the same gradual beginnings of apparently quite useless organs, the excessive skeletal outgrowths, which have been the harbingers of extinction in many animal groups, both vertebrate and invertebrate. If we knew more about those creatures' soft parts, we could perhaps elucidate

these problems. Some light is thrown on them by recent work of Professor Julian S. Huxley and others. They have shown that in certain animals growth of the whole body leads to disproportionate growth of one part. Thus, in a group of crabs, whenever the body doubles in weight, the large claw increases three times, until it becomes almost as large as the rest of the animal. Any cause promoting growth of the whole body, therefore, leads to a disproportionate growth of the claw. And such a cause is to be found in competition within the species, more specially the competition between males for females by fighting, as is common among mammals, rather than display, as seems to be the custom with many birds.

Still, the possibility of some deeper underlying cause of evolution is often suggested by the study of a whole great group, such as ammonites, which furnish the best available material, for the following reasons. They were sea-beasts, hence their shells were preserved far better than the skeletons of land animals. The number of their known fossil species is nearly double that of living mammals. Their shells tell us of their development, for the whorls formed by the young animal are preserved in the middle of the complete structure. Finally, their history is over. The last of them died in Eocene times, forty million or more years ago. The earliest forms were often not coiled at all, and

always had very simple patterns on the sutures between different shell-chambers, and their descendants still made these simple patterns in embryonic stages. In the great ages of ammonites during the first two-thirds of the Mesozoic era, the most complex ornamentation was generally made by the adult animal. But as time went on, it showed a tendency to slur its work. The most complex patterns were made by the half-grown creatures and in cretaceous times the adult shells were even uncoiled, as in the very earliest forms. Now, this "second childhood" occurred independently in some scores of different lines of descent, always as a prelude to extinction. In other groups, the same phenomenon may be observed, though the stigmata of the generation are different.

This degenerative process is often described as the old age of a race, but we must remember that this phrase is only a metaphor. Some very obvious explanations for it are as follows.

A step in evolution in any animal group is followed by an evolutionary advance on the part of their parasites. When our fish ancestors came out of the water, they lost their louse-like crustacean parasites, and it was only after some time that insects can have taken their places and later still that micro-organisms such as those of malaria and typhus were evolved, which pass part of their life-cycle in insects and parts in vertebrates.

So, the apparent degeneration of a group may only mean that evolution of their enemies has caught up with their own. Again, specialisation, while it leads to temporary prosperity, exposes its species to extinction, or at least to very unfavourable conditions when its environment alters. A small change of climate will lead to a disappearance of forests over a wide area, and with them of most of the animals highly adapted to life in them, such as squirrels, woodpeckers, wood-eating beetles, and so forth. A few, like our own ancestors, adapt themselves to a new environment; but the majority, and all the more highly specialised, die out, the new population of the area being recruited from among the less well adapted forms. Also, as pointed out above, competition within the species, man included, may lead to results desirable for a few individuals, but most undesirable for the species as a whole.

To my mind, the closest analogy to the evolution of a given group is the history of the art and literature of a civilisation. The clumsy primitive forms are replaced by a great variety of types. Different schools arise and decline more or less rapidly. Finally, a period of general decline sets in, characterised by archaism like that of the last ammonites. The history of an animal group shows no more evidence of planning than does that of a national literature. But both show orderly sequences which are already pretty capable of explanation.

To sum up, no satisfactory cause of evolution other than the action of natural selection on fortuitous variations has ever been put forward. It is by no means clear that natural selection will explain all the facts. But the other suggested causes are unverified hypotheses, while selection can be observed by those who take sufficient trouble. Some of the alleged causes, moreover, are difficult to reconcile with the facts of paleontology and genetics. The evidence as to the earth's age from radio-active minerals shows that about 700 million years have elapsed since the first known fossils were laid down, and perhaps twice as long since life appeared on the earth. This is a larger time than the early supporters of Darwin demanded, and seems long enough to satisfy any quantitative objections as to the slowness of evolution. There are qualitative objections, such as those connected with the origin of consciousness. But consciousness arises anew in every human being. Its first origin on the earth presents no more and no less mystery than its last.

Finally, no facts definitely irreconcilable with Darwinism have been discovered in the sixty years and more that have elapsed since the formulation of Darwin's views. Such a fact would be, for example, a convergence in the course of geological time of members of two or more groups to form a single species. Actually, we observe the convergence of forms as we go down and not up a geological series. And there have been quite enough anti-Darwinian

paleontologists to have seized on such a case had it existed. As an explanation of evolution, Darwin's ideas still hold the field to-day, and subsequent work has necessitated less modification of them than of those of his contemporaries in physics and chemistry. Just as physiology has found no case of interference with the order of nature as revealed by physics and chemistry, the study of evolution has brought to light no principle which cannot be observed in the experience of ordinary life and successfully submitted to the analysis of reason.

CHAPTER V

THE EVOLUTION OF MIND

BY DR. JOHN R. BAKER

JUST because we live civilised lives, we almost begin to think that we have scarcely any of the primitive instincts which would have been of use to our ape-like ancestors. But deep inside us, we still have those instincts, which often come to the surface in emergencies. You can easily prove to yourself that you have them.

Ask some friend whom you know to be a really bad driver to take you out in his car. Relax and allow your mind to wander where it will. Your friend decides to overtake another car round a blind corner. Here is a car coming straight towards you. Now look at yourself. What are you doing ? You are holding on firmly to something or other. It may be the door-handle, or the dash-board, or part of your seat, or even your friend's arm, or worse still, the steering wheel, but the fact remains that, if your friend has really succeeded in frightening you, you will probably be holding on to something.

Now, holding on is perfectly useless to you, and so it would be to any terrestrial animal. But think how absolutely essential it is to animals which live in trees. If they had not got a strong instinct to hold on when frightened, then they would often fall to the ground in emergencies, and get killed. If our arboreal ancestor had not had that instinct, he would have fallen to the ground and got killed. And you and I would not be here to-day.

Here is another way in which you can show a primitive instinct at work, but it is rather more troublesome. If there is a large wood in your district, the middle of which is far from any house or road, go along to the middle of it at about 1 a.m. and walk about it a bit. You are very likely to find an almost overpowering instinct to return at once to the society of other human beings. It is not simply fear of the dark. People who are not in the least afraid of the dark in ordinary circumstances, are afraid of walking about alone in woods at night. This instinct must have been of great importance to our pre-human ancestors. The carnivorous enemies of early man would soon account for anyone who was foolish enough—or rather sufficiently lacking in this instinct—to walk alone in woods at night. Carnivores are far less likely to attack if two or more persons or animals are together, and this instinct completely fails to appear if two or more people are present. Our ancestors must have been specially easily

attacked in woods at night compared with most animals. Their sense of smell, like ours, must have been poorly developed, so that they could not win approaching enemies. Further, they must have been very defenceless before they took to using weapons, for their canine teeth had become reduced from their huge primitive dimensions. Their ability to escape by climbing was small in comparison with that of an ape with an opposable big toe. Escape by running would be difficult in a wood. No wonder that instinct not to wander alone in woods at night was strongly developed.

My brother informed me that he found no such instinct while sitting in trees waiting for big game in Indian jungles at night, but that he experienced the strongest instinct not to descend. It seemed possible that this disinclination to descend might be rational and not instinctive in an Indian jungle, where there are actual more dangers on the ground than in trees. I therefore decided to test the matter in a wood in England, where there could be no question of a rational fear, since there was no danger. In order to make sure that the instinct would appear, I got a friend to bring me into a wood which I had never been near before, and leave me in it. I had no compass, no whistle, no stick, and no match for light of any sort. I here quote my notes made directly after I left the wood. I have thought it best to present them exactly as I wrote them down.

" At first I stood still, and no instinct appeared. Then, I began to walk, and found an instinct not to. However, I did walk, but instinctively very silently, putting my feet down slowly and as noiselessly as possible. I forced myself to crash along for half a dozen steps a few times while in the wood, but found it quite hard to force myself. When I made an unexpected noise in walking, I instinctively stood stockstill, without moving any part of my body, even if I chanced to be in a peculiar position, as when stooping to pass beneath a bough. When I heard an unexplained noise not made by myself, I instinctively turned my head towards the source of the noise, or partly towards it, and remained stockstill, however peculiar my attitude chanced to be. I was constantly glancing back over my shoulders and felt my back insecure. When I walked along quietly, giving all these instincts full play, I felt fairly comfortable, but I was extremely uncomfortable while forcing myself to crash along. Nevertheless, I did feel an instinct not to walk at all, very strongly, and specially to remain still with my back to a big tree.

"I did not feel any instinct to climb a tree; but when I climbed one, I immediately felt perfectly happy and unconcerned, and did not care whether F. came back or not, except that I was afraid that I might fall if I went to sleep. I did not want to descend the tree and start walking again at all, but made myself do so. When on

the ground again, I felt anxious to get back to the branches of the tree, although I did not feel like that until I had once experienced the sense of security that the branches of the tree gave me.

"I climbed the tree again, descended again, and climbed again, and renewed the sensations produced before.

"F. returned and brought me out of the wood. The feeling of security given by climbing was surprising to me. I was very skeptical about it before. I have written this down directly on my return to F.'s house. I must record that I felt just like what I imagined a wild animal feels like when walking about in the woods—alert, suspicious, on the *qui-vive*, all the time except when in the tree."

Anyone who doubts the reality of these feelings should repeat this experiment. It is essential that he should be in a strange wood, with no way of finding his way out, and he must be quite alone, and it must be in the middle of the night.

It appears to be quite possible that we are only terrestrial by tradition and not by instinct. Our instincts may still be arobereal, as in many children. In exactly the same way, the other is not instinctively aquatic. Far from it. Every young otter must be forced by its mother to enter the water against its will. It must be taught by its mother to swim. I could give you

many instances of importance of tradition in animals. The wild children who have occasionally been found, have usually been arboreal, and their extreme agility in trees has made it difficult to catch them. It should be recalled too that most people preferred to go upstairs to bed.

Perhaps this consideration of primitive instincts will have paved the way for a comparison of the brain of man and apes. It is important to remember that we may not be so superior to the ape as we seem, for this reason. Much of our apparent cleverness is due simply to the ability of our minds to comprehend what others have discovered and communicated to us by speech and writing. Speech and writing tend to give us a very conceited impression of our own brains, for they enable us to profit from the wisdom of the ages in a way which would be totally impossible to the chimpanzee and orangutan, even if, except in the matter of speech, he had the same innate mental powers as we have. There is no evidence that the innate intelligence of man has increased in the slightest degree during the historical period. Discoveries have been made, and speech and writing have enabled these to be broadcast, so that each generation piles on new knowledge and discards what it proves to be erroneous. Thus, knowledge increases, but it seems certain that the brain is not evolving.

I think there can be no doubt that articulate speech separates us more from animals than

anything else. Without speech, what knowledge of the Universe should we have to-day? Fancy yourself cast off on an uninhabited island as a child before you had learned to speak. Suppose that it was a land flowing with milk and honey, so that you did not simply die at once. How much would you find out about the Universe before you die? One cannot say, but it would be very little. Do you think you would have been able to distinguish six objects from seven? Certainly, it seems unlikely that you would have got as far in the multiplication table as twice two make four. When we think of the great geniuses of history, we must appreciate the great extent to which they rely on the world's store of knowledge existing at their time in the form of speech, whether spoken or written. Speech, and specially written speech, enables us to start where our ancestors left off. The elementary student of biology to-day knows more about evolution than Charles Darwin ever did.

Can any ape speak at all? It all depends on what we mean by speech. The gibbon and the chimpanzee certainly have vocabularies. Definite sounds, which we can reproduce by phonetic spelling, have definite meanings. But none of these sounds indicate anything except emotional states. The chimpanzee can say something meaning "Extremely pleased", or "Very fond of you", or "Bored", or "Hostile". But he has no name for any concrete object, nor even for a banana, or a tree or water.

The evolution of speech in our sense must have started by some of our pre-human ancestors beginning to attach definite sounds to definite concrete objects. The great advantage accruing from even a crude form of speech would result in the natural selection of the speakers and their offspring in the struggle for existence.

Apart from speech, is there such a tremendous gap, after all, between a man's mind and an ape's? It is incredibly hard to know what is going on in the mind of an animal. When I see a cow, I often think to myself: what an extraordinary blank in knowledge its mind represents. I know its anatomy perfectly well and a certain amount about its physiology. The world's store of knowledge on these subjects is immense and almost incredibly detailed. But its mind! When it lies there chewing the cud, I have not the very slightest idea what it is thinking about, or if it is thinking at all. Is it turning over the events of the day, or wondering about the future, or is its mind an almost impenetrable fog, like our own when we are half asleep? Has the cow consciousness at all? This question does not seem at all ridiculous when we consider what complicated things human beings can do without consciousness when they are sleep-walking.

Animal-lovers step in where scientists almost fear to tread, and they have produced amazing and quite incredible stories about the sagacity of the dog. These stories are quite useless to anyone who

really wants to explore the minds of animals. They are recorded by wholly uncritical people who are quite unable to view a dog's behaviour objectively, but are carried away by emotion and love of the remarkable. I should be the last person to minimise the intelligence of the dog, for I have always lived with dogs, and I am very sensible of the astounding capacity they have of interpreting inflexions of the human voice, and also of recognising voices. One of my dogs never paid the slightest attention to the wireless, until he heard me broadcast. The moment I started to speak, he recognised the voice, and paid attention to the wireless for the first time. But such incidents as these really lead nowhere. They are not much more helpful than the obviously untrue dog-stories. There once existed a club in Oxford whose function it was to invent dog-stories to send to a weekly paper. A good deal of shrewdness must have been needed to gauge the editor's credulity.

After stories of this kind, a little objective research into the mind of animals comes like a breath of fresh air into an ill-ventilated room. Professor Koehler, of the University of Berlin, has made such an objective research into the mind of chimpanzees and has described it in his book "The Mentality of Apes". While nearly the whole civilised world was proving its civilisation by mutual destruction in the world war, he was carrying out his really thrilling investigations

in the island of Teneriff. Professor Koehler had no pre-conceptions, no desire to make out that his chimpanzees were more or less intelligent than they were. His idea was simply to test their intelligence in an entirely impartial way.

The tests he devised were excellently thought out and quite different from the usual tests. Let me tell you what he was *not* doing. He was not testing their ability to imitate human beings, or to learn to perform complicated actions. He was not testing them as so many people have tested animals, who think they are testing intelligence when really they are doing nothing of the sort. A favourite method with these others has been to put the animal in a cage from which it can only escape by pressing a button which releases a door. In more complicated tests, the animal has to move several buttons and latches in a certain order. The mistake in all these tests is that the mechanism of the action of the button in releasing the door is invisible, and though the animal soon learns the trick, it can have no insight whatever into its mechanism. People who have experimented in this sort of way have often concluded that animals are wholly lacking in intelligence, but really it would be as sensible to say that a man was wholly without musical taste, when one had only tested his capacity as a weight-lifter.

What, then, was the essence of Professor Koehler's experiments? Simply this, that in every experiment the whole situation of the problem set should be clearly visible to the chimpanzee.

The experiments were performed by putting food where a hungry chimpanzee could see it, but could only get it if it exercised intelligence. The simplest test of all is to put a banana outside the bars of the cage with a string attached to it. All the chimpanzees tested at once pulled the string and obtained the fruit. Dogs are generally nonplussed by this, though it would be simple for them to pull the string with their teeth, if they had the intelligence to comprehend the situation.

If a stick lies in the cage and a banana is placed outside, out of the reach, the behaviour of the chimpanzee depends on where the stick is placed. If it is placed in such a position that it can view the banana and the stick at the same time, it uses the stick as an implement to drag the fruit towards the cage. If, however, it cannot see the stick at the same time as the banana, it seldom has the sense to use it though it may look straight at the stick from time to time.

In solving these and other problems, it is clear that the chimpanzee has a real grasp of the situation. It is not that it behaves at random in the first instance, till by luck it secures the fruit, and that afterwards it repeats identically the same movements of the same muscles as gave success before.

On the contrary, the ape acts stupidly for a time, and then suddenly grasps the situation. From that moment, its action is sure and decided, in marked contrast with undecided movements a moment before. Next time the same problem is seen, it solves it more quickly, but often by quite different movements of its body. Success comes from mental grasp of the situation, and not from repetition of certain bodily movements which chanced to bring success before.

Curiously enough, chimpanzees are extraordinarily stupid about removing obstacles, though quite sensible about using tools. If a box is placed inside the cage in such a position as to prevent the ape from getting into a position from which it could reach a fruit placed outside, only the most intelligent of the chimpanzees have the sense to remove the box; and even they take a long time to see the obvious solution of the difficulty.

The chimpanzees become accustomed to obtaining fruits placed high-up, out of reach, by swinging on a rope attached to a horizontal beam. This gave an idea for an excellent experiment. The rope, instead of hanging free, was wound round the horizontal beam in three neat loops, not crossing one another. It now became apparent that three neat loops appeared to a chimpanzee precisely as a hopeless tangle appears to us. They all tried to untangle the rope, but quite unmethodically, just as we often try to straighten a tangle of

string quite unmethodically. If our brains were much more efficient than they are, we should straighten tangles with sure, decided, movements, never making the tangle more complex. Before judging the chimpanzee too harshly, however, we must remember, as Professor Koehler remarks, that many of us find a deck-chair as inextricable a tangle as a chimpanzee finds three loops of rope.

What is the limit of chimpanzee intelligence? I think that this is the hardest test that any of Professor Koehler's animals passed. The fruit is placed out of reach outside the bars of the chimpanzee's cage. A stick is provided, but it is hung on the wall so high up that it can only be reached by dragging a box below it and climbing on it. It takes a very clever chimpanzee to see what to do.

Professor Koehler considers that the chimpanzee may actually be nearer to man in intelligence than to many of the lower species of monkeys.

I cannot here discuss the expression of the emotions in animals. Charles Darwin wrote a fascinating book on this subject. On the whole, the chimpanzee expresses his feelings very much as we do, even to scratching his head when he is puzzled, and beckoning with his finger when he wishes his friends to approach.

Next time you see a chimpanzee in a cage, you will probably not view him with quite as contemptuous amusement as before. One should think how one would behave if one was shut up in

a cage oneself, and no privacy and no clothes, let us say in Japan, or in some other country where one could not make oneself understood. Of course, clothes give us a wholly artificial feeling of superiority. Someone has questioned whether we should have much respect for the House of Commons if members were compelled to sit in a state of complete nudity. Even the House of Lords would lose something of its dignity if subject to the same restriction. Yet, our respect should undoubtedly be for their brains and disinterestedness, and not for their clothing.

So far we have only discussed the changes in our outlook on the relationship between man and apes. Perhaps you will ask this, "Is that the only way in which the biological outlook has changed since the end of last century as far as the mind of man is concerned?" It is not, for many of our new ideas apply equally to man and to animals, profoundly affecting the way in which we regard man; so, now we must take a more general outlook on modern developments in the matter of the mind.

Probably you know what conditioned reflexes are. In case you do not, I may first of all remind you what ordinary reflexes are. If I were to touch your hand with a red-hot poker, a message would go along sensory nerves to your spinal cord, and another message would come back along your motor nerves to the muscles moving

your arm. Your whole arm would be pulled away with great speed, so quickly that the whole movement would be finished before the fact that you have been burned had arrived at your consciousness. Undoubtedly, a great number of our actions are reflex acts in which consciousness is not involved. Now, what are conditioned reflexes? If I were to play the note middle C on the piano, a great number of times, presumably it would not have any special effect upon you beyond being rather boring. But if I were to prick your finger with a needle every time I played the note, you would develop a reflex action of quickly drawing your hand away every time the note was struck, even though I no longer pricked you. This is a simple example of a conditioned reflex. Another example will make the subject even more simple.

When one is hungry, the smell of food causes a reflex secretion by the salivary glands, so that one's mouth waters. That is a simple reflex action. There is no question of voluntary action here, because you cannot make your salivary glands secrete by any act of your will. But conditioned reflexes often grow up round these reflexes. If a certain gong is used to summon you to your meals, just the mere sound of that gong will cause increased secretion by the salivary glands. Some very interesting experiments on this subject have been done with dogs. The conditioned

reflex of watering in the mouth at the sound of a bell is soon developed if dogs are always fed immediately after a bell is rung. There is no difficulty in showing that; because if you ring a bell, but produce no food, saliva pours out into the dog's mouth. That is simple, but here is something much more interesting and unexpected. If you always ring a bell, a quarter of an hour before you feed your dog, then your dog will develop a conditioned reflex of secreting saliva a quarter of an hour after the ringing of that bell.

It seems likely that conditioned reflexes play a large part in our ordinary behaviour. Many of our actions may be attributed to them, and this is an important and expanding field of research at the present moment. Nevertheless, it is possible that some enthusiasts have gone too far in regarding animal or human behaviour as almost exclusively made up of an infinitely complicated system of conditioned reflexes.

Then, there are the ductless glands. So much research has been done on them lately, and the results obtained have been so exciting, that they have found their way into the popular news-papers, despite the fact that their study is a branch of science. What are the most important conclusions that we can draw from the study, so far as the mind is concerned? That is fairly easy to answer.

We now see that many of our actions and emotions are by no means wholly to be ascribed to

our nervous system. There exist in our body definite glands which pour definite chemical substances into our blood-stream, which profoundly affect our thoughts and our actions. The most important are the thyroid glands near the adam's apple in the neck, the pituitary gland between the roof of the mouth and the brain, the adrenal glands near the kidneys, and the glandular tissue of the reproductive organs.

What are the effects of these glands? The straight-forward way to find out, is to remove them in the case of animals, and see what happens; or else we can notice what happens when they are diseased. Experiments and observations of this type have conclusively proved that our emotions are very largely controlled by chemical substances circulating in the blood which have been produced by the glands. It is interesting to note that the chemical substances formed in each gland are the same as in all mammals which have been investigated, including man. It has been possible in the case of some of the glands to isolate the actual chemical compound, and to analyse it, and in some cases to synthecise it in the laboratory.

The thyroid is the easiest gland to take first. Its secretion has the effect of increasing the rate at which bodily processes take place, and not only bodily, but also mental processes. The person whose thyroid gland is not functioning properly, is not only sluggish in his movements, but also in his

brain. He cannot help it. He must be provided with more of the essential substances secreted by the thyroid glands, and then he recovers. That is quite simple, because the substance is easily extracted from the thyroid glands of cattle or sheep killed for food. Sometimes, the thyroid gland of young children is almost wholly deficient, and then cretinism results. In extreme cases, the cretin may have the bodily appearance and the mental capacity of a child of two, when its actual age is ten times as great. This condition can be relieved by taking tablets of thyroid gland by the mouth.

Some people have not too little, but too much thyroid gland, which may succeed in secreting too much of the essential substance into the blood-stream. This results not only in undue physical activity and bodily restlessness, but also in an unduly active mind and mental restlessness. Such people are usually thin and have an agitated expression. The eyes often protrude from their sockets.

One must not fail to mention the adrenals. If you inject some of the secretion of the adrenal into a man, all the symptoms of fear are produced. The face goes white, the hair stands on end, the blood-pressure is increased, the heart beats strongly, so that its palpitations are easily felt, and the normal movements of the small intestine are arrested.

In the case of the reproductive organs, the matter is simple, for the development of the sex instinct depends on substances produced by the

reproductive glands. If they are removed in early life, these instincts never develop. By removing the reproductive organs from an animal, and grafting instead those of the opposite sex, one reverses its sex instincts. In this way, one may cause a male guinea-pig not only to produce milk, but also to acquire the instinct to suckle young.

There is no doubt that the mechanism is the same in man, and the utmost care should be taken in cases of abnormal sexual behaviour, to make sure that the glands are normal; for, if one were to punish a person for unusual behaviour when the glands were abnormal, one would be doing a grave injustice. You or I would behave abnormally if the inappropriate glands were grafted into us.

The fact of our relationship with animals is well shown by recent experiments performed in France. It was necessary to remove the ovary of a woman by an operation. A fluid was removed from the ovary, and injected into some ancient female rats which were so old that the sexual instinct had been lost. The result of the injection was that the instinct was immediately re-acquired.

It cannot be denied that the work on conditioned reflexes and on ductless glands has given us a more mechanistic conception of the mind. It seems much more probable now that the mind is a mechanism whose physical basis at least may one day be interpreted in terms of physics

and chemistry. I have only just been able to touch the very fringe of this subject. I wished that I could give you some idea of the enormous amount of work that has been done. The investigators have performed experiments and made observations which are repeatable. Everyone who doubts can experiment for himself. The more one studies, the more one is absolutely forced to the conclusion that chemistry plays a large part in the control of our emotions.

This raises the old problem of mechanism and vitalism. Are the body and mind to be regarded as a machine working simply according to the laws of physics and chemistry, or is there some fundamental distinction between animate and inanimate matter? It seems to me that to be a vitalist, is to fight a losing battle all the way. A hundred years ago, the first organic substance was synthecised from inorganic materials in the laboratory. Previously, it had been thought that such synthesis was impossible. This was the first blow to vitalism. No other organic substance was synthecised for some time, and the vitalists became optimistic that perhaps this was the one exception that proved the rule. But since then many such substances have been synthecised from inanimate substances in the laboratory, and to-day no one would claim that any particular substance in the body could never be synthecised. The vitalist simply says that he thinks that we

shall be unable to interpret life in terms of physics and chemistry. But the trouble is that every discovery in biology brings us nearer to such an interpretation. Every discovery makes his position less tenable.

Are we, then, to pronounce ourselves as mechanists? That, he will say, is the obvious alternative. Personally, I consider that it would be premature in the extreme to do so. We must only be mechanists when all bodily and mental processes have been reduced to mechanics, physics and chemistry, when we understand precisely what chemical and physical changes underly and constitute every part of every action, every thought, every memory, every emotion, even consciousness itself. As yet we do not begin to approach that position, and I consider that the only reasonable position to take up at the moment is that of skepticism. Nevertheless, let us remember that at present all discoveries in biology are leading us nearer and nearer to a mechanistic explanation.

* * *

The recent discovery that excessively small particles of matter do not obey the ordinary laws of physics, which are only applicable to large masses, has been interpreted by some as making probable the existence of free will. I agree with Professor Levy that any unprejudiced person, if he really thinks seriously on the matter, will agree that there is no connection between the two subjects.

CHAPTER VI

MAN'S PLACE IN NATURE

BY DR. JOHN R. BAKER

AS a result of the discoveries made in the last thirty years, (since the beginning of the century), we do not regard man exactly as we did at the end of the nineteenth century. I propose to give some account of the state of knowledge on this subject. Naturally, there will be accounts of observations and experiments which not everyone will be in a position to repeat, but if you doubt some comparison, for instance, between a gorilla skull and a man's, you should go to the museum, and look for yourself. I hope you will look in a zoo or museum at the apes to which I shall refer. Familiarise yourself with the gorilla, chimpanzee, orang-outang and gibbons, so that you could not mistake one for the other. There is sure to be a museum where you can see the chimpanzee, and there are, of course, other excellent zoos in other parts of the country. What I have to say will mean much more to you if you have a concrete idea of what the

animals are like, even if you cannot make an elaborate study of their anatomy.

Where is man placed in the animal kingdom to-day? He is obviously a mammal, that is, he stands in the same group as rabbits, and mice and cats and dogs and horses and cattle, which all have hair, are born in a fairly advanced condition, instead of being laid as eggs, and which are all suckled by their mothers after birth. There are, of course, many more characters which we have in common with the other mammals. Now, the mammals are divided into various orders; for instance, the rodents (the gnawing animals, rabbits and mice and guinea-pigs), the carnivores (flesh-eating animals like cats, dogs and bears), the ungulates (the hoofed animals, like horses and rhinoceros and cattle and sheep and camels and giraffes). Man quite definitely belongs in the same order as the monkeys, the order, *primates*, or nailed mammals. These are mammals with nails on their fingers instead of hoofs or claws, with two teeth on each side of each jaw before the canines, with the eye surrounded by a ring of bone, with well developed collar-bones, nearly always with ten fingers and ten toes, the thumb being opposable to the other fingers, and with two milk glands on the chest.

Now, where does man stand among the primates? First of all, we can separate off the lemurs, and say definitely that he does not belong there.

The lemurs are primates, but very primitive ones, with rather foxy faces, quite unlike monkeys in external appearance. Also they differ from monkeys and ourselves in not having the eye-cavity lined with bone all round behind, and also they have a claw instead of a nail on their second toe. Look out for that claw in the little lemur, but it is not always easy to see, as the animals often sit firmly on their hind feet as though they did not want you to see.

Not counting the lemurs, we have five families of primates. These are the marmosets, South-American monkeys, old world monkeys, the apes, and the man. By the apes, I mean the gibbons, orang-outang, chimpanzee and gorilla. Some of the monkeys are often called apes, but I think it is best to restrict the term in this way. Now, to which of the other families is man most closely allied? Not to the marmosets, obviouly, for they are curious little primates which cannot oppose their thumbs to their fingers and have claws on most of their toes and fingers, instead of nails. The South-American monkeys—that is to say, the monkeys with prehencile tails—are very different from man. The usual organ-grinder's monkey is one of these. Look at their widely separated nostrils. If you can obtain a skull, count the teeth. You will find they have six grinding teeth on each side of each jaw.

The old world monkeys, with non-prehencile tails, are much more like men, for their nostrlis

are close together and they have five grinding teeth on each side of each jaw, just as we have. Nevertheless, they have certain striking differences. Their grinding teeth are somewhat elongated from front to back, instead of being squarish, as ours are. Also many of them have curious swellings on their buttocks, and many have pouches in their cheeks in which they store food. Then again, their breast-bone is narrow, and they have no appendix and they usually have tails.

Now I have mentioned a number of ways in which the old world monkeys differ from men, and in every one of these points, the apes resemble men. There can be no doubt from comparative anatomy that the apes are closer to men than any other animals. We may not like to come next to the gorilla, chimpanzee, orang-outang and gibbon, but in our anatomy we undoubtedly do. I must repeat that the apes resemble us in having squarish grinding teeth, a broad breast-bone, an appendix, no swelling on the buttocks, no cheek-pouches and no tail. Further, they often walk on their hind-legs. The gibbon walks absolutely erect.

We do not come in the same family as the apes because we do differ from them in certain important respects. First and foremost, we have our big toe, which, as its name indicates, is the largest of our toes, which it never is in the apes. Then, our big toe can be opposed to our other toes, and our legs are longer than our arms and our jaws

stick forward less, while our chin sticks forward instead of receding, and our canine teeth do not project beyond the others, and we have not great bony ridges above our eyes, and we have far less hair, and last, but by no means least, our brain is very much bigger. It is very nearly the biggest in the whole animal kingdom, although we are so small compared to many animals. It is far larger than that of a cow or horse, and more than twice as big than the largest ape's brain. It is only exceeded in size by the brain of the elephant and certain whales.

These differences suffice to place us in a separate family, but probably we are more closely allied to the apes than the apes are to the old world monkeys.

I want to give you some idea of what it means to say that we are closely allied to the apes, but in a separate family. It means that in our anatomy, we are about as different from apes as antilopes are from deer, or as hyenas are from dogs. You must not suppose that that sort of comparison is very exact but it gives an idea of the scale of differences.

Now we have investigated the anatomy of man and his relations a little, but we have not considered the working of their bodies—that is, their physiology. Does man's body work in much the same way as that of apes, or are there radical differences, which show that man is not so closely allied to them as their anatomy would make us think?

A lot of work has been done on this subject recently, but it is incomplete, simply because it is so difficult and expensive to use apes as laboratory animals.

You know, of course, that gout is caused by uric acid which has an unpleasant way of collecting in joints. Now, what is this uric acid? It is a product of the nuclei of the cells in the food which you eat, and of the nuclei of the cells of your body. All mammals make uric acid in their bodies, but most of them turn about half of it into another substance, called allantoin, which does not get lodged in joints. The old world monkeys do this and so they are most unlikely to suffer from gout. But man has no capacity whatever of changing the uric acid into anything else, and so it must either be excreted as such, or else stored up in the joints in a most painful manner. I do not think that anyone has studied the gorilla or orang-outang in this connection, but Hunter has studied the chimpanzee and he has found that it exactly resembles man and differs from the old world monkeys and lower mammals. It has no capacity of changing the uric acid into allantoin. This agrees with our conclusion from anatomy that man is more closely allied to the apes than the apes are to monkeys.

Now let us take another branch of physiology and see how man compares with apes. Perhaps you have had occasion to give blood to someone else by

blood transfusion. If you have, you will remember that it is not everyone who has the right sort of blood to give to the person who happens to need it. If you have the wrong sort of blood for a certain patient, then his blood will destroy the blood corpuscles which you give him. Your blood corpuscles will all stick together in clumps and finally degenerate, and they will not be of any use to him. Nevertheless, your blood may be perfect for transfusion into the blood of somebody else, and if you are in urgent need of blood yourself one day, then the saving of your life by blood transfusion will depend on knowledge gained in experiments like the ones I am going to describe. These actual experiments were performed in America not many years ago by Landsteiner and Miller.

Suppose you take some blood of a Macaque monkey—which is an ordinary sort of old world monkey—and inject it into a rabbit, what happens? The blood of the rabbit gets the property of being able to make Macaque blood corpuscles stick together. You can take some of this rabbit's blood, and even if you dilute it enormously, it still possesses this power of making Macaque blood corpuscles stick together. It has the same effect on Baboon blood. Now, Macaques and Baboons are closely related; they are in the same family. So perhaps it is not very surprising that their blood corpuscles behave in the same way when put into this rabbit's blood. Even when enormously diluted,

this rabbit's blood causes Baboon blood corpuscles to stick together.

What about chimpanzee blood? Suppose you take some of it and mix it with some blood of the same rabbit as before which was previously injected with Macaque blood. What happens? Will it cause the chimpanzee's blood corpuscles to stick together? Scarcely at all. It is clear that chimpanzee's blood is very different from that of the Macaque and Baboon.

What about human blood? It is the same as with chimpanzee's blood. The rabbit's blood, which is so fatal to the blood corpuscles of the Macaque and Baboon, has scarcely any effect.

It is clear that in their blood relations man and the chimpanzee are equally distantly related to the Macaque and Baboon.

Take another rabbit, and inject human blood into it instead of Macaque's. Now, this rabbit's blood acquires the property of making human blood corpuscles stick together. Let us take some of this rabbit's blood and try mixing chimpanzee's blood with it. The chimpanzee's blood corpuscles stick together. Evidently, chimpanzee's blood is very much like that of man.

Is it exactly the same? Can we distinguish it by tests of this sort? Take some of this last rabbit's blood, which causes both human and chimpanzee's blood corpuscles to stick together. Put it in a glass vessel and go on adding

chimpanzee corpuscles to it until all the substance which causes chimpanzee corpuscles to stick together is used up. Now filter it, and you have got rabbit's blood which has practically lost its capacity to make chimpanzee's corpuscles stick together. Now make the crucial test, add human blood. It still causes them to stick together. Even when enormously diluted, it still retains that property. So you see, you can distinguish chimpanzee's blood from man's blood by tests of this sort, but only in rather a round-about way.

There is one way in which man differs very much from most wild animals, and that is in not having a breeding season. It. is true, of course, that more births occur at one time of the year than at another, and this is specially so among the Eskimos, but on the whole, we can say that the human race is without a special season. This was thought to be a peculiarity of man, and perhaps a result of what we might call domestication. Several domestic animals have lost their breeding season as a result of domestication. Unlike their wild relations, the cow and the pig breed all the year round. Mr. Zuckermann has been looking into this matter lately, and he has come to the conclusion that man, after all, is not so peculiar in not having a breeding season, because he finds that many old world monkeys lack one and breed at any time, producing young ones at all seasons of the year.

I must just mention one theory which Professor Wood Jones has lately been suggesting. He thinks that we are descended from animals like Tarsius, and not from an ape-like ancestor at all. Tarsius is a little lemur which is very different from all the other lemurs. He lives in trees in the Malay Archipelago and is a most extraordinary little animal with huge eyes. Certainly he does resemble us more than the other lemurs do. His muzzle has been very much shortened, just as ours has, but perhaps that is not very significant, for so has the bull-dog's for that matter. A more important point is the socket for his eyes, which is nearly walled in with bone behind, and not open as it is in other lemurs. Then again, its after-birth is a lumpy sort of thing, as with us, instead of having a membranous texture, as it has in other lemurs. But in both these points, Tarsius resembles monkeys and apes just as much as it resembles man. Possibly the common ancestor of monkey, apes, and man was an animal allied to Tarsius, but it seems very unlikely that we are more closely related to Tarsius than to apes.

The general conclusion which we have reached is that the recent physiological work, on uric acid and blood tests, confirms the older anatomical evidence that the apes are man's nearest relatives.

CHAPTER VII

MAN AS A RELATIVE BEING

BY JULIAN HUXLEY

DURING the present century, we have heard so much of the revolutionary discoveries of modern physics, that we are apt to forget how great has been the change in the outlook due to biology. Yet in some respects, this has been the more important. For, it is affecting the way we think. We think and act in our every day existence. Without the discoveries and ideas of Darwin and the other great pioneers in the biological field, from Mendel to Freud, we should all be different from what we are. The discoveries of physics and chemistry have given us an enormous control over lifeless matter, and have provided us with a host of new machines and conveniences, and this certainly has reacted on our general attitude. They have also provided us with a new outlook on the Universe at large: Our ideas about time and space, matter and creation, and our own position in the general scheme of things, are very different from the ideas of our grand-fathers.

Biology is beginning to provide us with control over living matter—new drugs, new methods of fighting disease, new kinds of animals and plants. It is helping us also to a new intellectual outlook, in which man is seen not as a finished being, single lord of creation, but as of one among millions of the products of an evolution that is still in progress. But it is doing something more. It is actually making us different in our natures and our biological behaviour. I will take but three examples.

The application of the discoveries of medicine and physiology is making us healthier : and a healthy man behaves and thinks differently from one who is not so healthy. Then, the discoveries of modern psychology have been altering our mental and emotional life, and our system of education : Taken in the mass, the young people now growing up feel differently, and will therefore act differently, about such vital matters as sex and marriage, about jealousy, about freedom of expression, about the relations between parents and children. And, as a third example, as a race we are changing our reproductive habits: The idea and the practice of deliberate birth-control has led to fewer children. People living in a country of small families and a stationary or decreasing population will in many respects be different from people in a country of large families and increasing population.

This change has not been due to any very radical new discoveries made during the present

century. It has been due chiefly to discoveries which were first made in the previous century, and are at last beginning to exert a wide effect. These older discoveries fall under two chief heads. One is Evolution—the discovery that all living things, including ourselves, are the product of a slow process of development, which has been brought about by natural forces, just as surely as has to-day's weather or last month's high tides. The other is the sum of an enormous number of separate discoveries which we may call physiological, and which boil down to this: That all living things, again including ourselves, work according to regular laws, in just the same way as do non-living things, except that living things are much more complicated. The old idea of "vital force" has been driven back and back until there is hardly any process of life where it can still find any foothold. Looked at objectively and scientifically, a man is an exceedingly complex piece of chemical machinery. This does not mean that he cannot quite legitimately be looked at from other points of view—subjectively, for instance. What it means is that so far as it goes, this scientific point of view is true, and not the point of view which ascribed human activities to the working of a vital force quite different from the forces at work in matter which was not alive.

Imagine a group of scientists from another planet, creatures with quite a different nature from ours, who had been dispassionately studying the

curious objects called human beings for a number of years. They would not be concerned about what we men felt we were, or what we would like to be, but only about getting an objective view of what we actually were, and why we were what we were. It is that sort of picture which I want to draw for you. Our Martian scientists would have to consider us from three main points of view, if they were to understand much about us. (First, they would have to understand our physical construction, and what meaning it had in relation to the world around and the work we have to do in it. Secondly, they would have to pay attention to our development and our history. And thirdly, they would have to study the construction and working of our minds. Any one of these three aspects by itself would give a very incomplete picture of us.)

(An ordinary human being is a lump of matter weighing between fifty and hundred kilogrammes. This living matter is the same matter of which the rest of the earth, the sun, and even the most distant stars and nebulae are made. Some elements which make up a large proportion of living matter, like hydrogen and specially carbon, are rare in the non-living parts of the earth; and others which are abundant in the earth are, like iron, present only in traces in living creatures, or altogether absent, like aluminium or silicum. Nonetheless, it is the same matter. The

chief difference between living and non-living matter is the complication of living matter. Its elements are built up into molecules much bigger and more elaborate than any others known, often containing more than a thousand atoms each. And, of course, living matter has the property of self-reproduction; when supplied with the right material and in right conditions, it can build up matter which is not living, into its own complicated patterns.

Life in fact, from the "public" viewpoint, which Professor Levy has stressed as being the only possible standpoint for science, is simply the name for the various distinctive properties of a particular group of very complex chemical compounds. The most important of these properties are, first, feeding, assimilation, growth and reproduction, which are all aspects of the one quality of self-reproduction; next, the capacity for reacting to a number of kinds of changes in the world outside—to stimuli, such as light, heat, pressure and chemical change; then the capacity for liberating energy in response to these stimuli, so as to react back again upon the outer world—whether by moving about, by constructing things, by discharging chemical products, or by generating light or heat; and finally the property of variation. Self-reproduction is not always precisely accurate, and the new substance is a little different from the current substance which produced it.

The existence of self-reproduction, on the one hand, and variation, on the other, automatically leads to what Darwin called natural selection. This is a sifting process, by which the different new variations are tested out against the conditions of their existence, and in which some succeed better than others in surviving and in leaving descendants. This blind process slowly but inevitably causes living matter to change—in other words, it leads to evolution. There may be other agencies at work in guiding the course of evolution; but it seems certain that natural selection is the most important.

The results it produces are roughly as follows. It adapts any particular stream of living matter more or less completely to the conditions in which it lives. As there are innumerable different sets of conditions to which life can be adapted, this has led to an increasing diversity of life, a splitting of living matter into an increasing number of separate streams. The final tiny streams we call species; there are perhaps a million of them now in existence. This adaptation is progressive; any one stream of life is forced to grow gradually better and better adapted to some particular condition of life. We can often see this in the fossil records of past life. For instance, the early ancestors of lions and horses about fifty million years ago were not very unlike, but with the passage of time one line grew better adapted

to catching and eating large prey, the other grew better adapted to grass-eating and running away from enemies. And finally, natural selection leads to general progress; there is a gradual raising of the highest level attained by life. The most advanced animals are those which have changed their way of life and adapted themselves to new conditions, thus taking advantage of biological territory hitherto unoccupied. The most obvious example of this was the invasion of the land. Originally, all living things were confined to life in water, and it was not for hundreds of millions of years after the first origin of life that plants and animals managed to colonise dry land.

But progress can also consist in taking better advantage of existing conditions: for instance, the mammal's biological invention, of warm blood and of nourishing the unborn young within the mother's body, put them at an advantage over other inhabitants of the land; and the increase in size of brain, which is man's chief characteristic, has enabled him to control and exploit his environments in a new and more effective way from which his pre-human ancestors were debarred.

It follows from this that all animals and plants that are at all highly developed have a long and chequered history behind them, and that their present can often not be properly understood without an understanding of their past. For

instance, the tiny hairs all over our own bodies are a reminder of the fact that we are descended from furry creatures, and have no significance except as a survival.

Let us now try to get some picture of man in the light of these ideas. The continuous stream of life that we call the human race is broken up into separate bits which we call individuals. This is true of all higher animals, but is not necessary: it is a convenience. Living matter has to deal with two sets of activities: one concerns its immediate relations with the world outside it, the other concerns its future perpetuation. What we call an individual is an arrangement permitting a stream of living matter to deal more effectively with its environments. After a time it is discarded and dies. But within itself, it contains a reserve of potential immortal substance, which it can hang on to future generations, to produce new individuals like itself. Thus, from one aspect, the individual is only the casket of the continuing race; but from another, the achievements of the race depend on the construction of its separate individuals.

The human individual is large as animal individuals go. Size is an advantage if life is not to be at the mercy of small changes in the outer world: For instance, a man of the size of a beetle could not manage to keep his temperature constant. Size also goes with long life; and a man who only lived as long as a fly could not learn much. But there is a

limit to size; a land animal much bigger than an elephant is not, mechanically speaking, a practical proposition. Man is in that range of size, from hundred pounds to a ton, which seems to give the best combination of strength and mobility. It may be surprising to realise that man's size and mechanical construction are related to the size of the earth which he inhabits; but so it is. The force of gravity on Jupiter is so much greater than on our own planet, that if we lived there, our skeletons would have to be much stronger to support the much increased weight which we would then possess, and animals in general would be more stocky; and conversely, if the earth were only the size of the moon, we could manage with far less expenditure of material in the form of bone and sinew, and should be spindly creatures.

Our general construction is determined by the fact that we are made of living matter, must accordingly be constantly passing a stream of fresh matter and energy through ourselves, if we are to live, and must as constantly be guarding ourselves against danger if we are not to die. About five per cent of ourselves consists of a tube with attached chemical factories, for taking in raw materials in the shape of food, and converting it into the form in which it can be absorbed into real interior. About two per cent consists in arrangements—wind-pipe and lungs—for getting oxygen into our system in order to burn the food-materials

and liberate energy. About ten per cent consists of an arrangement for distributing materials all over the body—the blood and lymph, the tubes which hold them and the pump which drives them. Much less than five per cent is devoted to dealing with waste-materials produced when living substance breaks down in the process of producing energy to keep our machinery going—the kidneys, bladder and in part the lungs and skin. Over forty per cent is machinery for moving us about—our muscles; and nearly twenty per cent is needed to support us and to give the mechanical leverage for our movements,—our skeleton and sinews. A relatively tiny fraction is set apart for giving us information about the outer world—our sense organs. And there is about three per cent to deal with the difficult business of adjusting our behaviour to what is happening around us. This is the task of the ductless glands, the nerves, the spinal cord and the brain; our conscious feeling and thinking is done by a small part of the brain. Less than one per cent of our bodies is set aside for reproducing the race. The remainder of our body is concerned with special functions like protection, carried out by the skin (which is about seven per cent of our bulk), and some of the white blood corpuscles; or temperature regulation, carried out by the sweat glands. And nearly ten per cent of a normal man consists of reserve food stores in the shape of fat.

Other streams of living matter have developed quite other arrangements in relation to their special environments. Some have parts of themselves set aside for manufacturing electricity, like the electric eel; or light, like the fire-fly. Some, like certain termites, are adapted to live exclusively on wood; others, like lions, exclusively on flesh; others, like cows, exclusively on vegetables. Some, like boa constrictors, only need to eat every few months; others, like parasitic worms, need only breathe a few hours a day; others, like some desert gazelles, need no water to drink. Many cave animals have no eyes; tape-worms have no mouths or stomachs; and so on and so forth. And all these peculiarities, including those of our own construction, are related to the kind of surroundings in which the animal lives.

This relativity of our nature is perhaps most clearly seen in regard to our senses. The ordinary man is accustomed to think of the information given by his senses as absolute. So it is,—for him; but not in the view of out Martian scientist. To start with, the particular senses we possess are not shared by many other creatures. Outside backboned animals, for instance, very few creatures can hear at all; a few insects and perhaps a few crustacea probably exhaust the list. Even fewer animals can see colours; apparently the world as seen even by most mammals, is a black and white world, not a coloured world. And the majority of animals do not even

see at all in the sense of being given a detailed picture of the world around. Either they merely distinguish light from darkness, or at best can get a blurred image of big moving objects. On the other hand, we are much worse off than many other creatures—dogs, for instance, or some moths—in regard to smell. Our sense of smell is to a dog's what an eye capable of just distinguishing big moving objects is to our own eye.

But from another aspect, the relativity of our senses is even more fundamental. Our senses serve to give us information about changes outside our bodies. Well, what kind of changes are going on in the outside world? There are ordinary mechanical changes: matter can press against us, whether in the form of a gentle breeze or a blow from a poker. There are the special mechanical changes due to vibrations passing through the air or water around us,—these are what we hear. There are changes in temperature—hot and cold. There are chemical changes—the kind of matter with which we are in contact alters, as when the air contains poison gas, or our mouth contains lemonade. There are electrical changes, as when a current is sent through a wire we happen to be touching.

And there are all the changes depending on what used to be called vibrations in the ether. The most familiar of these are light-waves; but they range from the extremely short waves that give

cosmic rays and X-rays, down through ultra-violet to visible light, on to waves of radiant heat, and so on to the very long Hertzian waves which are used in wireless. All these are the same kind of thing, but differ in wave-length.

Now, of all these happenings, we are only aware of what appears to be a very arbitrary selection. Mechanical changes we are aware of through our sense of touch. Air-vibrations we hear; but not all of them,—the small wave-lengths are pitched too high for our ears, though some of them can be heard by other creatures such as dogs and bats. We have a heat sense and a cold sense, and two kinds of chemical senses for different sorts of chemical changes—taste and smell. But we possess no special electrical sense,—we have no way of telling whether a live rail is carrying a current or not unless we actually touch it, and then, what we feel, is merely pain.

The oddest facts, however, concern light and kindred vibrations. We have no sense organs for perceiving X-rays, although they may be pouring into us and doing great damage. We do not perceive ultra-violet light, though some insects, like bees, can see it. And we have no sense organs for Hertzian waves, though we make machines—wireless receivers—to catch them. Out of all this immense range of vibrations, the only ones of which we are aware through our senses are radiant heat and light. The waves of radiant heat we

perceive through the effect which they have on our temperature sense organs; and the light-waves we see. But what we see is only a single octave of the light-waves, as opposed to ten or eleven octaves of sound-waves which we can hear.

This curious state of affairs begins to be comprehensible when we remember that our sense organs have been evolved in relation to the world in which our ancestors lived. In nature, for instance, large-scale electrical changes hardly occur. The only exceptions are electrical discharges such as lightening, and they act so capriciously and violently, that, to be able to detect them, would be no advantage. The same is true of X-rays. The amount of them knocking about under normal conditions is so small that there is no point in having sense organs to tell us about them. Wireless waves, on the other hand, are of such huge wave-lengths that they go right through living matter without affecting it. Even if they were present in nature, there would be no obvious way of developing a sense organ to perceive them.

As regards light, there seem to be two reasons why our eyes are limited to seeing only a single octave of the waves. One is that of the ether vibrations raying upon the earth's surface from the sun and outer space, the greatest amount is centred in this region of the spectrum; the intensity of light of higher or lower wave-lengths is much less, and would only suffice to give us a dim sensation. Our

greatest capacity for seeing is closely adjusted to the amount of light to be seen. The other is more subtle, and has to do with the properties of light of different wave-lengths. Ultra-violet light is of so short a wave-length, that much of it gets scattered as it passes through the air, instead of progressing forward in straight lines. Hence a photograph which uses only the ultra-violet rays is blurred and shows no details of the distance. A photograph taken by infra-red light, on the other hand, while it shows the distant landscape very well, over-emphasises the contrast between light and shade in the foreground. Leaves and grass reflect all the infra-red, and so look white, while the shadows are inky black, with no gradations. The result looks like a snowscape. An eye which could only see the ultra-violet octave, would see the world as in a fog; and one which could see only the infra-red octave, would find it impossible to pick out lurking enemies in the jet-black shadows. The particular range of light to which our eyes are attuned gives the best-graded contrast.

Then, of course, there is the pleasant or unpleasant quality of a sensation; and this too is in general related to our way of life. I will take one example. Both lead-acetate and sugar taste sweet; the former is a poison, but very rare in nature; the latter is a useful food, and common in nature. Accordingly, we most of us find a sweet taste pleasant. But if lead-acetate were as common

in nature as sugar, and sugar as rare as lead-acetate, it is safe to prophesy that we should find sweetness a most horrible taste, because we should only survive if we spat out anything which tasted sweet.

Now, let us turn to another feature of man's life which would probably seem exceedingly queer to a scientist from another planet—sex. We are so used to the fact that our race is divided up into two quite different kinds of individuals, male and female, and that our existence largely circles around this fact, that we rarely pause to think about it. But there is no inherent reason why this should be so. Some kinds of animals consist only of females; some—like ants, have neuters in addition to the two sexes; some plants are altogether sexless.

As a matter of fact, the state of affairs as regards human sex is due to a long and curious sequence of causes. The fundamental fact of sex has nothing to do with reproduction: it is the union of two living cells into one. The actual origin of this remains mysterious. Once it had originated, however, it proved of biological value, by conferring greater variability on the race, and so greater elasticity in meeting changed conditions. That is why sex is so nearly universal. Later, it was a matter of biological convenience that reproduction in higher animals became indissolubly tied up with sex. Once this had happened, the force

of natural selection in all its intensity became focussed on the sex instinct, because in the long run, those strains which reproduce themselves abundantly will live on, while those which do not do so will gradually be supplanted.

A wholly different biological invention, the retention of the young within the mother's body for protection, led to the two sexes becoming much more different in construction and instincts than would otherwise have been the case. The instinctive choice of a more pleasing as against a less pleasing mate—what Darwin called sexual selection—led to all kinds of beautiful or striking qualities which in a sexless race would never have developed. The most obvious of such characters are seen in the gorgeous plumage of many birds; but sexual selection has undoubtedly modelled us human beings in many details—the curves of our bodies, the colours of our lips, eyes, cheeks, the hair of our heads, and the quality of our voices.

Then we should not forget that almost all other mammals and all birds are, even when adult, fully sexed only for a part of the year; after the breeding season they relapse into a more or less neuter state. How radically different human life would be if we too behaved thus! But man has continued an evolutionary trend begun for some unknown reason among the monkeys, and remains continuously sexed all the year

round. Hunger and love are the two primal urges of man: but by what a strange series of biological steps has love attained its position!

We could go on enumerating facts about the relativity of man's physical construction; but time is short, and I must say a word about his mind. For that too has developed in relation to the condition of our life, present and past. Many philosophers and theologians have been astonished at the strength of the feeling which prompts most men and women to cling to life, to feel that life is worth living even in the most wretched circumstances. But to the biologist, there is nothing surprising in it. Those men (and animals) who have the urge to go on living strongly developed will automatically survive and breed in greater numbers than those in whom it is weak. Nature's pessimists automatically eliminate themselves, and their pessimistic tendencies, from the race. A race without a strong will to live could no more hold its own than one without a strong sexual urge.

Then again, man's highest impulses would not exist if it were not for two simple biological facts—that his offsprings are born helpless and must be protected and tended for years if they are to grow up, and that he is a gregarious animal. These facts make it biologically necessary for him to have well-developed altruistic instincts which may, and often do, come into conflict with

his egoistic instincts, but are in point of fact responsible for half of his attitude towards life. Neither a solitary creature like a cat or a hawk, nor a creature with no biological responsibility towards its young, like a lizard or fish, could possibly have developed such strong altruistic instincts as are found in man.

Other instincts appear to be equally relative. Every one who has any acquaintance with wild birds and animals, knows how much different species differ in temperament. Most kinds of mice are endowed with a great deal of fear and very little ferocity; while the reverse is true of various carnivores like tigers or Tasmanian Devils. It would appear that the amount of fear and anger in man's emotional make-up are greater than his needs as a civilised being, and are survivals from an earlier period of his racial history. In the dawn of man's evolution from apes, a liberal dose of fear was undoubtedly needed if he was to be preserved from foolhardiness in a world peopled by wild beasts and hostile tribes, and an equally liberal dose of anger, the emotion underlying pugnacity, if he was to triumph over danger when it came. But now they are on the whole a source of weakness and maladjustment.

It is often said that you cannot change human nature. But that is only true in the short-range view. In the long run, human nature could as readily be changed as feline nature has actually

been changed in the domestic cat, where man's selection has produced an amiable animal out of a fierce ancestral spit-fire of a creature. If, for instance, civilisation should develop in such a way that mild and placid people tended to have larger families than those of high-strung or violent temperament, in a few centuries human nature would alter in the direction of mildness.

But it is not only in regard to instincts and feelings that our mind bears the stamp of the world around. Bergson, the French philosopher, has gone as far as to suggest that the very way our thinking processes work is adapted to practical needs. To satisfy the primary needs of life, man must handle and deal with definite, separate material objects; to get a general picture of the continuity of things in space or time is not so pressing. In general, it is what we call intellect which thinks in the first way, about separate objects; and what we call intuition which thinks in the second way, about whole situations. Bergson points out that the evolution of our minds has been largely determined by the practical necessity of thinking in the first way, and that the way men think is not the only way in which thinking could be done. On the contrary, in a different kind of world, organisms might develop in which most thinking was intuitive.

If these ideas of Bergson's are perhaps a little speculative, they are nonetheless worth reflecting on, as showing how the human mind is doubly

imprisoned—it is imprisoned in its own way of thinking and feeling. And this way of thinking and feeling is itself in a way imprisoned in the material world about it. When we come to another fundamental property of our minds, however, we are on firmer ground. I mean our capacity for forgetting. This is usually taken to be a natural property, or at least a natural imperfection of mind. And a certain amount of our forgetting does seem to be due to this. A great deal, however, quite definitely does not, but owes its existence to the practical needs of our life.

To a large extent, we forget what it is convenient for our own purpose to forget. If we ever do get a chance to see ourselves as others see us, it is generally a shock to find how many inconvenient facts about ourselves and our actions, which are all too prominent in the minds of others, have been forgotten by ourselves.

Pavlov has shown how even dogs can be made to have nervous break-downs by artificially generating in their minds conflicting urges to two virtually exclusive kinds of action; and we all know that the same thing, on a higher level of complexity, happens in human beings. But a nervous break-down puts an organism out of action for the practical affairs of life, quite as effectively as does an ordinary infectious disease. And just as against physical germ-diseases, we have evolved a protection in the shape f the immunity reactions of our blood, so

we have evolved oblivion as protection against the mental diseases arising out of conflict. For, generally speaking, what happens is that we forget one of the two conflicting ideas or motives. We do this either by giving the inconvenient idea an extra kick into the limbo of the forgotten, which psychologists call suppression, or else, when it refuses to go so simply, by forcibly keeping it under in the sub-conscious, which is styled repression. For details about suppression and repression, and their often curious and sometimes disastrous results, I must ask you to refer to any modern book on psychology. All I want to point out here is that a special mental machinery has been evolved for putting inconvenient ideas out of consciousness, and that the contents and construction of our minds are different in consequence.

Our current ideas, our feelings, our scientific discoveries, our laws, even our religions, are moulded by the social environments of the period. We live in a more or less scientific age: It is all but impossible for us to know what it would feel like to live in a community which believed chiefly in magic. It is equally impossible for us, living in an age of nationalism, to look forward and know how people would feel and behave in a unified, supernationalist world. We find it impossible to understand how our great-grandfathers tolerated child-labour and slavery; it is likely that our grandchildren will find it equally impossible to understand

how we tolerated capital punishments or our present penal system.

But I have said enough, I hope to give you some idea of what is implied by calling man a relative being. It implies that he has no real meaning apart from the world which he inhabits. Perhaps this is not quite accurate. The mere fact that man, a portion of the general stuff of which the Universe is made, can think and feel, aspire and plan, is itself full of meaning, but the precise way in which man is made, his physical construction, the kinds of feelings he has, the ways he thinks, the things he thinks about, everything which gives his existence form and precision—all this can only be properly understood in relation to his environment. For he and his environment make one interlocking whole.

The great advances in scientific understanding and practical control often begin when people begin asking questions about things which up till then they have merely taken for granted. If humanity is to be brought under its own conscious control, it must cease taking itself for granted, and, even though the process may often be humiliating, begin to examine itself in a completely detached and scientific spirit.

CHAPTER VIII

MAN AND REALITY

BY JULIAN HUXLEY

IN the first contribution to this series, I tried to give a picture of man as a relative being—to show how his construction, his ways of working, and even his way of thinking, are only comprehensible in relation to his environment. I shall now attempt something, I fear, rather too ambitious,—I shall attempt to show some of the ways in which the changed picture of life given by modern biology, is helping to determine a change in the general picture of the world which we can draw for ourselves. For, you must remember that man's general picture of his world evolves just as much as man himself. Indeed, it must evolve—it cannot stay still: the very notion of fixity of dogma, or of knowledge, or of ideas, is an error, and is wrong. One of the greatest marks of the modern world is the realisation that, while truth must always be incomplete, it yet can be progressive.

In recent years, several men distinguished in physical science have given us a lucid account of

their world-picture. Like all modern world-pictures, it has a basis in the facts and theories of science, and extends over into philosophy. I will not presume here to expound their views, which have after all been published and widely discussed. But there is one point about them by which a biologist cannot help being struck. The picture which emerges is of an observer contemplating the world from the outside, as Jupiter was supposed to contemplate Earth from the vantage point of heaven. The observer is not so much an individual human being, but rather an artificial creation—the human intellect, or perhaps better, the human intellect as represented by the highest achievements of mathematical physics. And the world observed is not so much the concrete world as the ordinary man observes it, but a world with all its qualities taken out of it, except what can be weighed and measured—a world of mass, space, time and energy, a metrical, mathematical, world.

That is all very well. It may be the simplest method of approach for the physicist. He is so accustomed to thinking in terms of inanimate things to be measured and reasoned about by his enquiring mind, that he has come to take the mind for granted as somehow outside the things with which he as a scientist is concerned. But this is not necessarily the only, or even the best, way. The biologist, for instance, cannot see the world in this way. He has a more difficult job, for he knows

that his mind is just as much a part of the things which he as a scientist has to investigate as is his body or the lifeless world around him. He must try to account for the observer as well as for what is observed: He cannot be content to leave mind outside the field of his facts, but must make it, too, part of the subject-matter of his science.

To understand the situation properly, we must look back a moment at the history of thought. What I am going to say about the so-called primary or secondary qualities of things is rather unfamiliar or perhaps difficult; but it is of the greatest importance for understanding the change which has recently come over scientific philosophy. Children, savages and primitive philosophers are alike in believing that the qualities of objects are somehow in the objects. They would say that in an orange for instance, there inhere the qualities of being round, yellow, having a certain pleasant taste, of weighing so much, and being of such and such a size. But with the rise of the scientific method in the seventeenth century, people began to distinguish between different kinds of qualities of objects. Some of them are still thought of as belonging to the objects themselves: These were called primary. The fundamental primary qualities were mass—which they defined as the amount of weighable matter in a thing; and magnitude—its size and shape. But other qualities, it appeared,

were put into objects, so to speak, by us; and such were called secondary qualities. Colour is an example, and so are taste and smell. An ordinary man sees an orange as yellow; but to someone who is totally colour-blind, it simply looks grey. And, of course, even before this, common sense as well as science had learned that, whenever man ascribed emotion or will or purpose to a lifeless object, they were just projecting their own feelings into it. Savages think of the thunder as a manifestation of anger, because they are frightened by it. Early religions put benignity and power and wisdom into their idea of the sun, because the sun warms man, ripens his crops and looks down upon the earth.

Thus, first of all, will and emotion were taken out of objects, and then all the secondary qualities so that nothing was left but what we could weigh and measure directly.

But to-day we are reaching a new stage. For one thing, we are seeing that the so-called primary qualities are not any more in the objects than are the secondary. They are just the most convenient ways—most convenient, that is, from the point of view of science—of describing how objects appear to us. They are the most convenient because they can easily be measured in terms of quantities which all human beings agree about. Furthermore, other qualities can be referred back, so to speak, to these standards; colour, for instance, can

be referred back to light-waves of a particular speed and size, hitting a special kind of chemical substance in the retina of our eye.

But they need not be thought of as in the objects. So far as we can get a picture of physical reality, the world is not made up of bits of matter of a definite size and mass, moving at definite speeds, like innumerable tiny billiard balls careering through space. That was the first crude idea of the picture revealed by modern physics with its discoveries of atoms and electrons. But now we are beginning to realise that, instead of the ultimate units of matter being like our idea of ordinary material objects, only much smaller, they are something wholly different. They are centres of energy, whose effects shade off into remote space. As Whitehead has forcibly set down for us, every portion of the Universe would seem to be in mutual interaction with every other.

We have no way of picturing such centres of energy, save by an effort of the scientific imagination. They have, however, certain properties which we can measure in the shape of mass, and others which we can get hold of by measuring distances and speeds. Thus, far from the so-called primary qualities being peculiarly in matter, we simply take over the idea of mass, distance, and speed from our every-day experience of matter as it presents itself to our senses; we find we can use them to get at and measure certain aspects

of the behaviour of those ultimate units of the world; and from the knowledge we thus get of their behaviour, we can build up some, doubtless rather inaccurate, picture of what they really are like. It is only for matter as perceived by our senses—an orange, a table, a stone—that the primary qualities are any more real than the secondary ones. To the physicist, the table is an arrangement of energy more condensed at innumerable tiny centres, reduced almost to blank space between the centres; and in regard to that picture of the table, the ideas of mass and size are just as much put in by man's mind as is the table's colour, just as much the consequence of the way man works as is the colour the consequence of his eye containing certain kinds of pigment in its cells.

There is another point. The development of relativity theory has shown that these so-called primary qualities are not even unchangeable. For instance, an object going at a very high speed, changes slightly both in mass and shape. If from the point of view of the physicist, the properties of matter which we call mass and extension, turn out to be merely certain measurable effects of the underlying arrangement of energy centres, from the point of view of the mathematical philosopher, like Einstein, they turn out to be variable properties of a single system—what he calls the space-time-continuum—in which matter, space and time are all inextricably blended, of which they are all merely

aspects which we artificially isolate in our thinking. In either case, they disappear as primary essential qualities of matter, and remain only as those manifestations which we human beings can most conveniently get hold of by accurate measurement.

Does all this have any real bearing on practical life, on us as actual human beings? Is it not all too abstruse and fine-spun?

I do not think so. It seems to me to have quite definite bearings upon various ideas which, consciously or unconsciously, go to make up our general attitude to life; and, of course, our general attitude to life must in the long run influence the way we live.

To begin with, it does in a certain sense put man back in the central position from which science in the beginning had pushed him out. Obviously, it is not the identical position. Science gives no support to the idea that man is in any sense a privileged being, living in the physical centre of the Universe, with the rest of the world created for his use or pleasure. But it establishes human beings as the highest things of which we have knowledge; and it establishes human mind as the one agency which brings order out of the mere chaotic hurly-burly of experience. Either we must give up in despair, or we must trust our own nature. The human mind has created sciences, religions, arts, mathematics, philosophies, moralities. On the whole, there has been definite progress in

these constructions of our mind. We, therefore, have more reason for confidence than for despair. But it must be a confidence in ourselves and our own human powers, not an appeal to something external. It is in that sense that man is re-established in a central position.

And, of course, this way of thinking brings mind into the scientific picture. The physicist sees the world as an assemblage of matter and radiation, but forgets to take proper account of the fact that he is able to see it and reason about it all. In his picture, human mind remains a mere spectator, outside the drama, and wholly unaccounted for. But if, as all physiology tends to show, man is not just a body plus a mind, but a body-mind, body and mind being two aspects of his single nature; and if, as all general biology tends to show, he has evolved from lower forms of life, and life in the final analysis has evolved from matter which was not alive; why, then, something of the same general nature as mind must exist not only in other forms of life, but even in lifeless matter.

Thus, knowledge and feeling and will are not just something tacked on, so to speak, to a mechanical Universe, but the Universe is seen to comprise two aspects, one objective and mechanical, the other subjective and concerned with mental and emotional and spiritual happenings; and neither is more real or true than the other.

Finally, mind is not just static. It changes; it too, like body, is evolving. And the ideas which man's mind hammers out concerning the world which it inhabits are in a mental sphere like machines in the physical sphere. They do a particular piece of work more or less adequately. Just as modern hydro-electric plants or textile mills are great improvements on water-mills or hand-looms, so our mental machinery for obtaining, ordering and controlling knowledge and thought, has improved enormously from what it was among the cavemen or in the time of Moses, in its evolution to the present-day world-picture based on science. But equally, like our machines of metal and glass and electricity, it is capable of indefinite farther improvement.

The straightforward materialism of science from the seventeenth to the nineteenth century rid us of the idea of magic, and took purpose out of nature. It was no longer necessary or even reasonable to suppose that the stars required guidance in their courses—or at least, any more guidance than a stone dropping to the earth, or a stream running down-hill. It was no longer necessary or reasonable to imagine that plants and animals, including man, had been specially created, when variations and natural selection would account for their evolution. It became as illogical to pray for rain as it would have been to revive the practice which once seemed wholly natural and sensible, of

making sacrifices and carrying out fertility rites to make the crops grow. It destroyed the idea of infallible dogma in the intellectual sphere, and put in its place the conception of a slowly growing changing body of knowledge.

But there it stopped. It was still in some ways the unchanging spectator outside the world. It could not see itself clearly as part of the evolving Universe, it could not yet grasp that its ideas and its very method of thinking about things must change as result of its interaction with new knowledge. Further, it had been so concerned with the intellectual sphere that it had hardly begun to extend its ideas into aesthetics and morals. Most nineteenth century scientists, for instance, though rejecting the idea of a fixed body of intellectual beliefs, still clung to the idea of a permanently fixed moral code-which happened, of course, to be that of their own age, nation and class.

To-day we are beginning to see that the idea of the Absolute, whether in truth, or beauty or virtue, is no more and no less than this: It is a necessary consequence of the humam faculty (the greatest single difference between man and lower animals) of being able to think in terms of abstract concepts. Once man can say "This is true and that is, false," he is setting up, even if often unconsciously, a standard of truth in the abstract. Once he can feel "This is wrong," he has set up an abstract standard of right. But it is an abstraction : The actual truth

which he possesses is always only more or less true, the actual morality which he practises only relative to the ideas and the circumstances of his time.

The physicist, like Sir James Jeans, tells us that mathematical analysis comes nearest to describing reality ; and he feels driven to postulate a divine creator or ruler who is responsible for the mathematical order in the Universe. But just here, the biologist, with his relativist view, feels very suspicious. Surely the physicist, just because he is accustomed to leave mind out of his scientific picture, and yet because mind just refuses to be left out altogether, has put it back again in the form of a divine mind. But the mathematical order in the Universe can just as well be thought of as merely the product of the mathematician's wonderful analysis, just as scientific laws are not laws in the ordinary sense, imposed from outside by a law-giver, but are simply the most convenient ways which the scientist can find of describing how things work.

The biologist is just tempted to say that Sir James Jeans finds a mathematical divinity ruling the Universe, just because he himself is such a good mathematician—another example of the human tendency, as Voltaire put it, of creating god in man's image. So, Paley, impressed with the evidences of purposeful design in nature, (evidences which Darwin later showed could better be explained without conscious purpose, by natural selection), made the Deity a divine artificer; so, the early

warlike Jews, before the time of the Prophets, made Jehovah a jealous and wrathful divinity.

His own picture is rather a different one. He does not believe that the present state of our knowledge permits any deduction as to the ultimate nature of the Universe, its first creation, or final fate, its possible purpose.

Scientific and mathematical laws are one of the ways of our thinking about nature's happenings. They are the most convenient way of abstracting reality in terms of pure intellect, and also the most convenient way, in the long run, of securing practical control over external nature.

Art is another method of our minds for dealing with phenomena; and religion is yet another. Anyone of these ways can be more or less good and true in its own sphere; but however true they may be in their own sphere, they do not and cannot apply to the others in their sphere. And, of course, that being so, life is more than science or art or religion alone, and indeed more than a mere addition of them and other separate faculties of life.

In any case, the absoluteness of scientific truth, or religious feeling, or artistic rightness, is something which derives from us. The only immediate reality we know is the stream of raw experience. Science is but one way of arranging this experience in accordance with the laws of our thought. The scientific picture, like any other ordered picture of the Universe, is an abstraction.

But the biologist can go one step farther. He does not feel able either to assert or to deny that mind, in the shape of a universal or divine mind, is behind the changing Universe he knows. But he can see that mind is an integral part of that Universe. Something of the nature of mind must inhere in the essence of things. Under the particular conditions found on this planet, the pressure of conditions has forced mind to become more and more important and elaborate, until finally in man it has become self-conscious and the most important single characteristic of the stock.

Life may be a consciously planned experiment on the part of a divine mind—or it may not. But in any case, it is legitimate for us to say, on the basis of the known history of life, that mind has become the great progressive feature of life's evolutionary trend. So that, even if our art and religion and science, are only our own ways of arranging the jumble of experience, yet in attempting these arrangements, we are carrying on with the main trend of evolution. The biologist finds it exceedingly difficult to believe with the pessimists and the skeptics that human life means nothing. It is a part of a larger whole, and of a whole with a main upward movement. To continue that trend, is to fulfil evolutionary destiny. Clear thinking, deeper feeling, and stronger willing are the chief means of achieving that end. That, I think, is the biologist's chief contribution to our changing picture of the world.

CHAPTER IX

THE PARADOX OF SCIENCE

BY PROFESSOR HYMAN LEVY

THE last century has seen such a development of scientific knowledge that the time is past when any one person can hope to have a detailed understanding of the whole field of science. Around the fire-side we may be wiseacres, understanding everything from stainless steel to smoking chimneys, but there is no scientific man who would dare to claim expert knowledge about many different problems. Take that little packed cylinder of tobacco you may be smoking at the moment—I do not know a single scientist who would claim to know all about tobacco-growing, about the manufacture and composition of cigarette paper, and whether smoking is harmful or not. Yet, these are only three of the many highly technical questions one might discuss.

Again, in spite of much popular misunderstanding, science is not a definite, clearly defined body of knowledge. It is never possible to say that this or that is the last word on any scientific

subject. On the contrary, science is continually expanding; it is in a continuous state of change. Yesterday matter was thought to be the fundamental stuff of which our Universe was made, this morning it was atoms, this afternoon it was electrons, this evening it is something much less definite, a wave, radiation. What will it be to-morrow?

Here is a piece of paper; it has shape and size, a certain chemical make-up, a definite weight. I might be able to describe all these aspects of the paper with great apparent accuracy, and yet I cannot tell you why it is that, when I try to lift the paper by one corner, the rest of the paper is lifted with it. How is it that all these exceedingly small particles—molecules, atoms, electrons —which science offers as the basic stuff of matter, hold together in the shape of this paper, so that it moves as a whole when I pull one corner? It is amusing to realise that no scientist who values his reputation would assert that he really knows the answer. An adequate reply to this apparently straightforward question might make all our previous description of its weight, shape and chemical composition, look quite different. You see, scientists are trying all the time to upset their own equilibrium. They are continuing digging away at their foundations. What anchor-hold on such shifting sands, you may well ask, can science give?

The fact is, of course, that science prides itself on this capacity for change. It is prepared to take every scrap of verified evidence into consideration, whether or not it accords with the personal likes or dislikes of the investigators themselves. It is the solid basis of assured knowledge, continually and relentlessly accumulating by this process, which provides the anchor-hold of science. That this anchor must be constantly tested, is clear, and so the evidence upon which scientific fact rests, must be continually examined and overhauled. It is impossible, therefore, to state what science is, at any one time, without describing also the process by which science acquires its facts. We have to realise, moreover, that these facts are collected and interpreted by man. Now man possesses certain limitations which we must not underrate, for they affect these interpretations very profoundly. Man's picture of the world is not like a photograph. True, he handles, at close quarters, the impersonal objects of his world—the "earth, air, fire, water," animals and plants, atoms and electrons—but his observation and understanding of these things depend also on his senses; his interpretation is influenced by his inheritance and by his environments.

When at birth he is plunged into this changing world, he enters into two main heritages. In the first place, he has acquired a bodily structure, apparently complete, with bony frame, muscles

and sense organs, a bodily organisation which evolved through countless generations from early forms of life. The range and power of his sense organs sets limits to what he can see, hear and smell and feel. Scientific instruments—telescopes, microscopes, weighing machines, telephones and so on—have only comparatively recently extended his power of perception. He cannot see the bones of his body. He can only feel the position of some of them. An X-ray apparatus, however, can help his eyes and his fingers do these things. In the same way, he is unaware, unaided, of the beautiful colours in the inside of his body. The soft tread of a fly, and the murmur of dust being deposited all around him, is not distinguishable by his ear, but a microphone could enlarge these sounds to the patter of hail. Such a magnification makes one realise how limited are our direct powers of perception.

In the second place, man inherits a social environment. Most of us are born into a home, have school companies, friends and acquaintances. We find ready-made institutions, books which have been read and laws which have been obeyed for hundreds of years—a mass of established tradition and belief. All these influences surround us from birth with rules of conduct, social taboos and prihibitions, shaping the greater part of our behaviour and colouring our thoughts until we die. Our attitude towards our parents or our children,

to individuals in other social classes, towards religion, politics and so on, is more or less determined by this social environment. We have customs and beliefs which are scarcely more than historical relics of our savage origin. We have taboos about food and about thunder. We are still very close to primitive man in outlook, temperament and social background—a fact which becomes evident in times of danger and great excitement. It is easier to see the caveman in others than in ourselves. Only about ten thousand generations, after all, separate us from our savage ancestors. I can imagine my parents and grand-parents and all my ancestors standing in succession, one behind the other, stretching southwards to the sea. Only my grandfather, my father and myself are aware of the existence of this procession, and we do not know its full significance. But looking back along the line, we can see that long before the procession had reached the outskirts of Greater London, our ancestors have become naked wandering savages. Throughout Surrey and Sussex, they became increasingly ape-like, and by the time the sea is reached they can hardly be distinguished from the tail-less apes. Civilisation is almost within earshot. Our ancestors were agriculturists and metal workers on the threshold of this building, and in the passage outside, they are reading books and presently suggesting that the way to find out about the world is to make experiments with it.

So here you see man's historical background—the background which we must never forget when we discuss the meaning of our science, our religions and our philosophies. At each successive stage in history, man is apt to regard his explanation of the world as final and complete, ignorant of the fact that his explanation is little more than a reflection of the ideas and beliefs of his own particular scene in this historic pageant.

When I set out to tell you what science is, or indeed when any one sets out to tell you *really and truly* what anything is, as if the explanation were the last word on the subject, you will, I hope, find yourself doubting its finality. All explanations must be examined in their evolutionary setting. I stress this point because our newly found ability to look at ourselves and our ideas in this way, is, to my mind, one of the most significant changes that have been brought about by the science of the last century. That change is one of the greatest contributions of science to education. Whether educationists have, in their field, exploited the fact to the fullest possible extent, is another matter.

There is another reason why my task of defining science is difficult. The traditional picture of the scientist as a bespectacled individual, so emerged in his researches in his laboratory that he is unconscious of the havoc his work

is producing in the outside world, is not entirely a carricature. It is in fact often true. The scientist is usually so absorbed in his tiny specialised field that he rarely has time or opportunity to think about social effect of his labour or to look in perspective at the movement of which he is a unit. Science is a very absorbing pursuit, and it may be that the mental concentration which it requires provides an escape from the trials of every-day life. Nevertheless the time has gone when the scientist could legitimately separate himself from the rest of his fellow-men in the belief that his scientific interests were his own and that they affected no one. It is true that Farraday's early studies of electricity were primarily of laboratory interest. Later on, industrialists saw in the practical application of his work a possible source of fresh profits. But this generation, living in a world of electrical devices and of industrial disorganisation, is being taught by bitter experience that it is disastrous to keep science and its industrial applications in water-tight compartments. The scientist and his work cannot be separated from the rest of his changing Universe. Science has social roots and social consequences.

We are all of us continually making this false separation even with the most every-day things. For example, you have a pencil or a cigarette in your hand, and you easily think of it as a

thing by itself, a separately existing object. But is it? It is a cigarette—in your hand. Your hand is attached to your body, your body sits in a chair, the chair is on the floor, the floor is in a building, the building is on the earth, the earth is part of an assembly of planets careering round the sun, and the sun and our solar system are only part of other systems.

The point is that we easily separate off for examination tiny separate fractions—the solar system, the earth, the building, the floor, the body, the hand, the cigarette. But notice that we only do this for simplicity's sake, to make our examination more easy. The separation is nevertheless quite artificial. We cut our cigarette out of the Universe as if it were a separately existing entity. But there is no such thing as a cigarette in itself. No one has ever seen one; it is a figment of the imagination, a pure abstraction. In the same way, it is not easy to make ourselves remember that this cigarette we have so boldly plucked from the rest of the Universe is now different from what it was a moment ago, and from what it will be in a moment to come. There is a continuous process of change going on, so that to say our cigarette preserves its identity through time and space is also a pure abstraction. Of course, it is easy to appreciate this point when a burning cigarette is changing rapidly before our eyes, but the same considerations apply to everything else we so easily

call an object—a piece of iron, a stone, the planet on which we live. The world you and I perceive is a world of perpetual change of which we are an integral part.

I stress this point because I want to show you that our common sense way of looking at the world, regarding it as composed of a number of separate objects, may not tell us the whole story. Many of the growing-pains of science have arisen from this fact. Once an object has been separated off and given a name, we seem to expect the object to persist unchanged because the name persists.

What does it matter in practice? one may ask. Very little for most purposes. We do in fact live the greater part of our life as if the objects we handle were permanent and separate things. Fortunate it is for science that we do so, for much of its framework is in practice built round this conception of permanence. In the newer physics, however, these ideas matter a great deal. Only a few years ago, the indestructibility of matter and the indestructibility of energy were accepted almost as religious beliefs in science, so accurately did matter and energy maintain their separateness in practice. Then came the newer knowledge given us by the study of electricity and these hard and fast ideas of permanence had to be abandoned when radium and similar substances were found to discharge tiny electrified particles. In the face of an extended experience, the old abstractions of permanent

separate matter and permanent separate energy broke down. Matter in certain circumstances dissolved into energy.

These are not mere manufactured difficulties. The perplexities stand out as soon as one attempts to lay down a basis for accurate knowledge, and if one ignores them, one builds on a basis of falsehood. The answer to the question, "What is science?", is then no mere definition or form of words. It will be found by studying the scientist at work. Outside the realm of pure mathematics, there is little that can be described by mere definition. We can tell what anything is only by examining the process which exposes it, and by studying it in relation to the wider processes of which it is a part. We do not define things into existence.

I propose, then, to set out the position we have reached so far:

(1) We must regard any knowledge we acquire about the world in the setting of man's historical evolution.

(2) Both we ourselves and the world of which we are a part are in a continual state of change. It is untrue to say that there is nothing new under the sun. In a sense, there is something different under the sun every moment.

(3) These world changes penetrate to us through our sense organs. Not only are these limited in power and range, but they

also have an evolutionary history. Tools and scientific instruments are inventions for extending their powers.

(4) Science studies the changing world by the method of abstraction. The scientist separates off from the rest of the Universe any object he wishes to study. The method of abstraction sounds difficult. But it is, in fact, the method of ordinary discussion.

May I explain what I mean by the method of abstraction ? If you are considering how high a ball will rise when you throw it into the air, you are not concerned with the colour or chemical nature of the ball, or when and where the ball was made. You are concerned only with its shape, size and weight, and with wind resistance. Any other sphere with the same shape, size and weight would do equally well. We have ignored what, for immediate purposes, is irrelevant and have abstracted those things which are significant for the purpose in hand. From this process, there emerges a common principle at work on which one relies in explanation.

An abstraction, therefore, although it sounds complicated, is really a simplification. By means of abstraction, irrelevancies are stripped away and fundamental likenesses between different objects are thereby disclosed.

An explanation consists in describing complex events in terms of simplified abstractions.

"Well," I can hear some of you grimly remarking, "now we know." "Why is it," you ask, "that scientists use so many unfamiliar words that their talk sounds like a foreign language? Why cannot they bring themselves down to the level of the ordinary man?"

It is not pure perversity: there is a defence. A hen crosses the road, and I ask "Why does that hen cross the road?" A satisfactory answer is, apparently, "because she wants to get to the other side." I enquire how you know what the hen wants. You cannot tell me that your evidence of what the hen wants to do is derived from the fact that she actually does cross the road, for that would be begging the question. How do you know what the hen wants? You may dislike this persistence, for I suspect you have been transferring to the hen your own private feelings about roads and walking. When I begin to explain, however, how it is that the hen crosses the road, and I use in my explanation words like "external stimuli," "conditioned reflexes," "motor reaction," "visual reception," you begin to abuse me because I am talking a foreign language. The fact is that the whole question of language is a very vital part of the process of explanation and the means of arriving at scientific truth.

The scientist has to distinguish between two kinds of statement. In the first place, there are statements about the so-called external world (it

is not external, for we are pieces of it). For example, this room is twenty feet square. The paper is white. That note is E flat. These are statements that can be verified. I can communicate them to you with assurance, because I know that you can verify them if you take enough trouble. The verification may be extremely difficult, and most of us have to rely upon individuals with special knowledge and elaborate apparatus to verify them for us. For example, you will not be able easily to verify the statement that the speed of light is 186,000 miles per second. You have to rely for the truth of that statement upon the fact that this figure has been arrived at independently by scientists working in many different laboratories. It is with these public affairs that science operates, and only those things which can be verified publicly are included in the term scientific knowledge.

We may, nevertheless, receive pleasure from a public discussion on a private matter, on literature or on art. These are statements about private feelings. "The wind bloweth where it listeth," is poetry, not meteorology. A phrase like "Nature abhors a vacuum," is not a scientific explanation of the reason why a tube with one end closed, from which air has been expelled, immediately fills with water if the open end be emerged in that liquid; and yet the phrase "Nature abhors a vacuum" may be found in text-books even to-day. Science knows nothing about this ill-defined dislike

of a vacuum on the part of nature. Dislike is an expression of personal feeling. Of course, popular language is honey-combed with these expressions, and the language of a scientist appears dull and complicated to a layman, because the scientist has to exclude these poetic, colourful, but for scientific purposes meaningless descriptions. His explanations must be publicly verifiable.

To devote so much space to these considerations may appear excessive. It is this scientific method of public investigation, however, which has been mainly responsible for the vast changes in civilised life which have become apparent during the last hundred years. It has made ours a different world from that of our great-grand-parents. Yet it can hardly be said to be in common practice outside scientific laboratories. Man in fact has not yet caught up with his own method of investigation. He is one of the changing objects in this changing world, and he changes slowly. His schools and his laws, and those social institutions which settle so much of his beliefs and behaviour, still drag slowly behind. He still has vain imaginings, fears and personal egoisms which colour his discussion and argument.

One need not be learned in scientific matters in order to acquire the point of view I have here outlined. You will find, I suggest, that if you avoid private explanations in discussion, restricting yourself and your friends to public matters that can

be verified, truth will acquire a new and cleaner complexion. Motives will be verified not by personal assurances, but by an examination of actual behaviour. Discussions that might have finished in personal bickerings and estrangements may resolve themselves into collective attempts to obtain and examine evidence.

CHAPTER X

IS THE UNIVERSE MYSTERIOUS?

BY PROFESSOR HYMAN LEVY

I HAVE tried to show science at work behind the scenes in order that two things might be appreciated: First, the close contact with concrete things that science persistently maintains, and secondly, that nowadays scientific work is not an individual activity, but a corporate undertaking. It is carried on by large groups of workers dependent one upon the other for help, understanding, and verification, in order to distinguish it from personal or private belief.

I propose now to discuss a much more difficult question—one which has become prominent because of the efforts which are being made by some scientific men to interpret scientific discovery and to indicate to the man in the street the direction in which science is moving. Any attempt to do this is very desirable; for the day is long past when understanding of a powerful activity like science can remain the private possession of a few. But the manner in which it has been done, has revealed

what a difficult, even dangerous, undertaking it is. As I understand it, the function of a scientific expositor is, first of all, to reveal to his hearers the field within which science can operate, and secondly to interpret the facts of science within that field. A scientist, however, is also a private individual, and unless he has clearly delimited his public responsibilities, he is likely to be found gaily trespassing in a private region where science does not yet operate, and holding forth there about the things he "believes."

I cannot illustrate the dangers more clearly than by quoting from one of my correspondents. "Would you kindly inform me," one writer asks, "if you consider the statement 'There is no life after death' a scientific one, when you take into consideration the altered view scientists now take with regard to the atom." Nor is this the only occasion on which the same issue of the atom in relation to the "spirit" of man has been raised.

Let me say at once, lest there be any misunderstanding, that I would never say that there is no life after death. Having been unable, after much seeking, to obtain any satisfactory knowledge which would even enable to state in scientific terms what the phrase "life after death" means, I cannot yet say anything positive about it from a scientific point of view. My correspondent, however, goes further than I do. His question suggests that modern researches into the constitution of the atom

do provide some information about "life after death." I confess that I am completely baffled by the apparent relationship between atoms and immortality, and I doubt if the most sturdy believer in psychic research would countenance the suggestion of any relationship. And yet the belief is fairly widespread that in some peculiar way recent investigations into atoms and electrons point to the discovery of something "spiritual" at the core of scientific theory.

In order to clear the issue, let me first draw a distinction between two points. I want to contrast two questions: "Is science mysterious?" and "Is the Universe mysterious?" It is the latter question that appears as my title, but actually the question one invariably hears discussed is "Is science mysterious?" I want to show that the answer to this question is definitely "No." There is no mystery in science. You can make what answer you like to the other question, for it does not come within my province. If you ask me as a private individual what I feel about it, of course, I will tell you, but I should have to speak privately and my statement would merely have the standing of that of any other individual man or woman. It would not have the backing of the scientific movement.

One often hears it said by those who, having had no chance of getting their science at first hand, have had to rely on interpreted information,

that the world is not deterministic like the inevitable workings of a machine. They declare that the closer scientists penetrate into the workings of nature, the clearer it is becoming that, in the last resort, things happen of their own volition—which is, of course, only another way of saying, for no apparent reason. They say that this indeterminism or "free will" is to be seen in the minute details of the structure of the Universe—in the behaviour of the electron, and that it thus follows that in large-scale events old-fashioned determinism is dead, and that human free will is an established fact.

First let me say something about the historical setting of this theme. Of course, the Greeks argued about determinism, but its modern phase begins about the time of Newton in the seventeenth century. More than any other man, Newton organised into definite scientific laws our knowledge of certain aspects of nature—in particular, facts about the solar system. He showed that the movements of planets in the remote past fitted in with his generalisation, and that his laws could be used for purposes of prediction. Throughout the eighteenth and nineteenth centuries, the study of mechanics, with which Newton had been specially concerned—passed from success to success, and the application of the laws of mechanics to engineering practice was followed by remarkable achievements. Newton, who by the way was a very religious man—thus

unwittingly laid the foundations of a form of mechanical materialism which reached its zenith in the nineteenth century. The world came to be regarded as a vast complicated piece of machinery—a clockwork mechanism which, having once been set in motion, with all its intricate interlocking detail ran smoothly and relentlessly along its predestined course, according to the laws laid down by Newton.

Much has happened since that time to alter the setting of this picture, but from what I have already stated you will recognise that this mechanistic explanation was a highly public view of the world, a view which in actual fact has had tremendous success in explaining and describing the visible behaviour of material things, not only on our little earth, but throughout the solar system. Naturally, side by side with this outlook, there existed, and there still exists, that private view of human behaviour which says "I am master of my destiny, I can do this or that just as I wish ; my will is free." It was natural that all those institutions and opinions associated with the private belief in free will should feel that this powerful and successful piece of scientific machinery might at any moment try to explain away personal conduct as it had explained the machine. It is possible that they felt that any such attempt would be a threat to personal happiness. Therein arises the traditional antagonism between science and religion.

Now, certain things have happened in science to change this picture slightly. I refer to the theory of relativity and to the quantum theory. Not that I propose to explain either relativity or the quantum theory, but I shall try to show how these new theories affect the problem of determinism.

It would be well, first of all, to explain in greater detail what scientists mean by a "scientific law" and by "observed facts." Every one, given the right kind of apparatus and the right kind of skill, can verify "facts" for himself. Facts are the same for everybody. A "scientific law" is a general statement which covers and unifies observed facts. Let us take a simple example to show how the scientist arrives at his scientific laws.

You know those "Try your Strength" machines that one finds in fairs and recreation grounds and on piers—in fact, anywhere where there is time and money to waste. One is given a hammer and is told to strike upon a block; the strength of one's blow can be seen by the rise of a ball which travels up a column. If your strength is as the strength of ten, a bell rings, otherwise you fail to get your money back. The principle of the thing is that the strength of your blow is measured by the height to which the indicator rises. Suppose you strike the block with a certain known force and watch how high the indicator rises. Then, if you give the

block a blow twice the strength, you will find the indicator rise to about four times the previous height. Use three times the strength and the indicator rises to about nine times the height, and with four times the strength and the indicator reaches sixteen times its first height.

On seeing these figures, you say at once that there seems to be a rule or law which relates the strength of the blow and the height to which the indicator rises. I will state the law:

The strength with which the block is struck is proportional to the square of the height to which the indicator rises.

I want you to notice two things. First, we seem to be in a position to state that, if we hammer with five times the strength, the indicator will rise to five times five, or twenty-five times the height to which it rose on the first occasion. That seems obvious from the result already found. But I would remind you that there is no experimental evidence for it. In order to be absolutely sure, we should have to strike the block with five times the original strength and find out the height to which the indicator rose. It is true that we are induced by the results we have already obtained to make a scientific prediction about the behaviour of the indicator. A scientist would say that an induction had been made,—that is that from a series of observed facts, a wider law uniting them all had been formulated. Notice that in making our

induction we have over-stepped the experimental evidence. Far from being a definite assurance, about what will happen in the future, scientific prediction is merely a statement that under such and such definite conditions a certain result may be expected. In other words, that expected result would be consistent with our generalisation. Let me state this first observation categorically:

A scientific law is only a statement of what seems extremely likely to happen.

Scientific law does not deny that further facts may still come to light which are not in accordance with that law.

Second, it is often said that one of the objects of science is to state in advance what will be found in the future under given conditions—in other words, to predict future experiences. What do we mean by experience here? Consider the "Try your Strength" machine again. A blow had to be struck in order to observe the height to which the indicator rose. Now, when we double the striking force, we find that the height is not exactly quadruple, but only very nearly quadruple—sometimes the height is a tiny bit more, sometimes a trifle less. You might say this was an accident. Try again,—and let us suppose the machine is as perfect as science can make it, and that the required striking force can be exactly produced. On ten separate occasions, suppose the block be struck with exactly twice the strength. On no occasion does it rise

exactly to four times the height—only very nearly so. You will probably cast about in your minds for the cause of this apparent error. You say that it is so small that your observation must be at fault; that the ball which acts as an indicator "intends" to rise to exactly four times the height on each occasion, but for one reason and another, it fails to do so, and so on. But if you strike the block with twice the force a hundred times, or a thousand times, instead of ten times, you will still find the same small error. You will then turn your attention to an examination of the law, and you might come to the conclusion that the law as you had framed it was *too perfect*. You might say that a law to be a perfect law ought to embrace these minor errors of observation. You might say that you do not want an idealised law, but that you would prefer a working law, one that would give you the odds on getting one of a series of measurements, all, of course, very nearly equal. The fact that you have got an idealised law results from the method of abstraction which I have already discussed. By the method of abstraction, you have stripped off from the ball and from the blow all the things you imagined to be of no consequence in practice. You have got an idealised, or perfect, law. It may not, and generally does not, meet the observed facts of your real ball and your real blow.

You will see from all this that science makes idealised laws and uses them for predicting what is

likely to happen in the future. These future events may not be exactly as they are forecasted, but they should nevertheless approximate to the prediction.

So, if we look back on the rigid determinism of the nineteenth century, we see that it was too hard and fast. This rigid determinism took scientific laws as they were set out, sharply and clearly, by Newton and his successors, and assumed that they were the laws of nature. The assumption was made that, if only one measured accurately enough, one would find these laws exactly fulfilled. In other words, the determinism of the nineteenth century considered that these exact scientific laws were really nature's laws, and that what you actually found in the world of reality was only an approximation to those perfect laws. We now see, however, that this was putting the cart before the horse. Scientific laws no longer occupy the magnificent and impregnable position they once did. Whatever validity a scientific law has, is shown by the fact that the law is a good approximation to the operations that actually go on in this complex and changing world. Scientists repudiate the idea that it is possible to predict absolutely the features of the Universe.

We are now ready to turn to the recent researches connected with the electron and the quantum theory.

The electron is a scientific abstraction which is causing people a great deal of trouble. If only

one could get hold of a single electron and make experiments on it, one might manage to make short work of it, but electrons exist in groups and thus render themselves immune from too close a scrutiny. One has to deal, therefore, with the average of the group—the typical electron. Now, electrons are quite unlike anything that science has ever experienced in the whole course of her history, but electrons appear to be a basic constituent in matter, and so any discussion of matter at that level involves an explanation in terms of electrons. Hence our difficulties. First of all, let me remind you of the relation between atoms and electrons. For most purposes, a lump of matter—a piece of iron for example—behaves as a whole and remains one piece unless you sub-divide it. In describing the behaviour of this piece of iron, Newton's laws of mechanics approximately hold good. Now, in theory our piece of iron can be regarded as consisting of an enormous collection of atoms. During any chemical change, these atoms remain intact. Once an atom, always an atom, so to speak. But if you pour some acid over the lump of iron, it may dissolve. The lump of iron as a whole will have disappeared, but the atoms have not disappeared: they can all be accounted for. They will individually have united with the atoms in the acid. The presumed behaviour of individual atoms in a lump is only part of the story, however. For an atom, as you know, is supposed to consist of a charge of positive electricity

round which there circulate at incredible speeds, and at various distances from the central positive charge, one or more tiny electrons—like planets circulating round the sun. That is the theory. These whirling electrons are thought to be charges of negative electricity. From substances like radium, they are shot out naturally, and in the laboratory, they can be knocked out of the atom if you hit it hard enough with certain rays—metaphorically speaking, of course. Now the electrons move around the central charge at various distances from it, but on occasion they seem able to pass from one path to another path. We only deduce that they have changed paths, because they have radiated light in doing so.

It is necessary to digress for a moment in order to comment on the precision of our knowledge in these fields. Ultimately, of course, all science depends for its accuracy on the precision of experimental measurement. When we come to deal with the ultimate particles we call electrons, and try to measure distances and times—distances between two neighbouring electrons and times of passing from one path to another—we are working at the very limits of scientific experience. The very act of measurement affects the things we are trying to measure, for our effective measuring rods and the objects of our measurement are both ultimate particles. There is thus a fundamental difficulty of measurement in these fields. Suppose, for example,

you tried to find out how cold some object was by touching it with your hand, and suppose that every time you reached out to touch it, the heat of your hand caused it to melt. The same sort of situation is created in attempts to measure the electron. With the ordinary conventions of space and time used for measurements and predictions of speeds and distances—of largish objects, an odd thing happens when the tiny electron is measured. Its speed and its position cannot be measured independently. The more accurately you fix the speed the less accurately can you fix the position, and the more accurately you can measure the position, the less accurately can you measure the speed. Speed and position are not independent and separate aspects of a moving electron. If you wanted to predict where a particle was going to be at some definite instant in the future, you would, of course, require, to know where the particle is now, and at what speed it is passing through its present position. It is just the same for a train. If you want to know when the train from A. will arrive in B., you must know the time it started from A. and the speed at which it is travelling towards B. But unfortunately these two things cannot be found separately for the electron, so that you cannot describe in detail its behaviour as if it were an ordinary particle.

The reason for this difficulty is known. It resides in the fact that there is a minimum quantity

of energy—the quantum it is called—which is capable of taking part in any action. This quantum acts as a whole. There is no half-way house. A quantity of energy is either a quantum (or several quanta) or nothing. You cannot have a fraction of a quantum. As the electron moves on its journey and gets from one path to another, it gives out a quantum of energy which shows itself in the form of light. Now, this quantum of light does two things. It enables us to detect the presence of the electron, but at the same time, in being emitted, it jerks the electron right off its balance, so that we do not see the electron where it is, but where it was. In this way, it becomes impossible at the same time to fix both the position of the electron and its speed.

There is no mystery about the idea of the quantum, yet some writers have suggested in popular expositions that here is a problem that by its very nature eludes determination and so is a mystery. But I would ask you to remember this—these writers do not suggest that the electrons do not go along paths of some kind. They are prepared to state what proportion of a group is distributed along one path and what proportion along another, but they say that it is impossible to predict for an individual electron which path it will traverse. They can state how probable it is that it will go along this or the other path. So, there is really nothing here to create confusion.

Since it is known how the difficulty has arisen, there is nothing to support the feeling that mystery lies at the very heart of the Universe. After all, every scientific law ought to be stated only as a probability, and any prediction, as we have seen, is only a statement about what will probably happen.

The point I want to make is this. The newer physics in its study of the electron has merely made us recognise that there are limitations to the field in which man can make accurate predictions. This is not a new conception; it has been recognised in other spheres. Man is limited by the very nature of his sense organs. He is limited by his heredity and by his environment and by his social tradition. Even scientific truth is a limited and temporary statement depending on the state of knowledge of the time. It is true that a new limitation has been exposed by this work on the electron, but there is no mystery about it. It has not affected the determinism which was essential to scientific method before these recent developments in physics. Predictions which were made—and are still being made—on large-scale objects remain valid.

Finally, remember that what we have been discussing has nothing whatever to do with what is called the free will of human beings. Free will is a purely private belief, a purely personal interpretation of human conduct. Science does not take account of such beliefs. Next time you hear it

suggested that modern physics has knocked determinism out of science, I hope you will call to mind the considerations I have here put before you. Without determinism there could be no science.

CHAPTER XI

SCIENCE—DISRUPTIVE AND CONSTRUCTIVE

BY PROFESSOR HYMAN LEVY

LOOK around the room in which you are seated and draw up a list of things you can see in their natural state—just as they are found before they had been tampered with by man. There is coal on the fire, water in the glass, and possibly flowers in the vase. There seems to be little else. Among all this collection of things,—chairs, cutlery, books, wall-paper, clothing, curtains, electric switches, carpets, pictures, nails—what is there true to nature? Even the water might be soda water, the fire an electric one, and the flowers imitation.

The difficulty you have in finding "raw material" in your room, will impress on you the extent to which modern civilised life has come to depend for its necessities and luxuries on the refining processes of industry. Here are two pieces of paper, one is coarse but strong. I find it difficult to tear. It will not lie flat. I hold

it up to the light and find that there are uneven clots in it. The other piece is smooth and thin. When it is held up to the light, its texture is uniform. It lies flat and is suitable for writing on. Think of the amount of labour, skill and research that have gone to build up these two types of paper, each suitable for a special purpose. Here is a fountain pen with its iridium nib and its vulcanite container; there is a fireplace with its cast bars and ornamental tiles. Look at the carpet or curtain with its intricate weaving and fast dyes. All these things are of highly elaborate manufacture, dependent on the application of complex scientific processes. They are part of the ordinary furniture of our lives. In this practical guise, science has insinuated itsely so deeply into our homes, work and amusements, that we are as little aware of it as we are aware of our own breathing. It is not as if science were an old established tradition. There is scarcely an electrical device in common use at the present day that is more than thirty years old.

If these scientific amenities were suddenly withdrawn, our civilised life would crumble. Life would become impossible in our cities, with their large massed populations, dependent on the smooth running of power stations for the preparation of food, and on mechanical transport for its distribution. As a community, we have built on the

assumption that these things will go on, and that we may depend on science somehow or other to satisfy new needs and to overcome new dangers. Try to imagine what steps you would take to-day if it became known that by to-morrow morning every scientific discovery and invention of the past century would have vanished, leaving you to cope with the demands of home and communal life. I suggest this speculation not for idle amusement, but because I want you to appreciate what I mean when I say that we have staked our future and the continued functioning of our civilised life on a complete belief in science.

I should like to explain more fully some of the implications of this fact. Consider what Britain was like hundred and fifty years ago. It was a country with a much smaller population, a proportionately larger agricultural industry, a strong merchant class, and the small beginnings of industrialism. Then came the new sources of power, coal and steam, and the face of Britain rapidly changed. Corn-fields and pasture lands gave way to coal-mines and iron-foundries; quiet villages suddenly expanded into busy towns and the country-air was transformed into the smoky atmosphere of cities. The rural population marched steadily into the rapidly growing towns. In a generation, Britain gave herself over completely to the new mechanical age. Three facts are important. First of all, that the whole mode of life of the greater part of the population of this

country was completely changed in one generation. Secondly, that it was the discovery of new uses for steam, coal and iron which was the main factor affecting the structure of Britain's population—just as its structure had previously been largely determined by agriculture. And thirdly, that the kind of life which our grand-fathers built up in the towns rested on the assumption that the new movement was permanent and could be relied upon to last.

We have lived to see how false was that last assumption. The needs of a community are not static. Urged on by these changing needs, scientific investigation is itself a continual spur towards change. Moreover, scientific progress cannot be localised: it knows no national frontiers. Mechanisation spread rapidly but unevenly. Nor was it ever asked how much mechanisation was necessary to supply the world's needs, or which countries were best adapted to the process. In the absence of international action, acute competition in world trade resulted.

The immediate changes which followed the coming of the Steam Age were merely the prelude to a continuous transformation whose guiding force was the needs of the community. As science and technology satisfied each need, there followed far-reaching changes of a social structure. This consequence of events will come home to you if you try to draw up a list of the industries that have come into existence—not forgetting those that have

died in the mean time—during this past generation alone. Let us ask ourselves whether we or our friends would have found employment in our present trade or profession fifty years ago. Consider an industry like transport, and take note of the succession of horse, train, motor car, aeroplane.

Even "brain work" is highly mechanised: In insurance offices and banks one hears the soft hum of the computing machine, adding and subtracting totals and sub-totals. In the scientific laboratory, electrical machines perform the most complicated operations, differentiating and integrating, computing horizontally and vertically, enumerating the results, and even going to the length of recording mistakes. Not only is the machine thus taking the place of man, but it is making man's work more accurate. Steadily and relentlessly, hands and brains are being replaced by machines, and the making of these new machines becomes itself a development of industry. Let us examine one such development in detail.

When coal is heated in a particular way, three main products are separated out—coal-gas, coal-tar and ammoniacal liquor. As early as 1789, the manufacture of coal-gas was begun; fifteen years later, a public gas work was established. Gas-lighting spread. It was a social asset. The by-products of gas manufacture, however, were a social evil, and became a nightmare to works' managers. Lighting was a social necessity, but it

was equally a social necessity to get rid of its evil-smelling consequences. It was the scientist in the end, not the commercialist, who turned to a study of these waste-products. Bethell discovered that one of the oils from the waste coal-tar was an excellent wood-preservative, a discovery that led to a new industrial process and incidentally solved the nation's problem of rotting railway-sleepers. In 1825, Faraday isolated benzene in the laboratory. Twenty years later, benzene was discovered in coal-tar—coal-tar which had for years been thrown away by enterprising businessmen who had even paid large sums to have it removed. To pay to have it examined by a chemist was a notion which had not presented itself to them. In 1856, Perkin, a young chemist aged 18, while experimenting with aniline, a substance obtained from the benzene in coal-tar, discovered the first aniline dye. This dye was mauve, and its discovery marked the development of the modern dye industry with all its subsidiary interests.

The industries which have directly followed on a scientific study of these waste treasures of the coal industry are almost legion. Dyes of all shades, napthaline, ammonia, creosote, benzol, pitch, tar, perfumes, paraffines, drugs, flavourings, disinfectants—to say nothing of high explosives. Industries concerned with paint, India rubber, varnish and stain, composite fuel, wood-preservation, felt manufacture, to name only a few concerns, depend on the

salvage work of scientists who have rescued valuable raw materials from was terubbish.

The moral is clear. The present and future needs of a community cannot be provided for adequately and intelligently, unless appropriate machinery exists for the application and development of scientific principles in industry. From the birth of the scientific idea to the manufacture and sale of the finished product, there must be co-ordination.

A significant test of intelligent planning in industry can be made by examining the effectiveness of this machinery for adjusting supply to present and future needs, and of exploiting the natural resources of the country. In the application of science to industry, there are three important stages. First of all, the discovery in pure science has to be made. There are the physicists, chemists, biologists, biochemists, bacteriologists, in their respective laboratories, concerned mainly with fundamental theory, and the opening up of new fields of enquiry. Their work is carried out principally in the Universities, in Government scientific institutions, and in specialist museums and libraries. The results of their investigations are to be found in the journals of the learned societies—freely given to the world and often published at the expense of the investigator. These scientists struggle along, begging for grants towards the cost of apparatus and publication; and in the past, help has been given grudgingly, as a luxury which the community could ill afford—

although the history of technology has shown that scientific research is a vital necessity if communal life is to be developed successfully.

The next stage in the process brings us to the factory laboratory, where the theoretical idea of pure science has to receive an industrial baptism. The function of the industrial laboratory is best illustrated by an example. Take dyes. A new dye has been isolated from coal-tar by the chemist. How fast is it? How does the crude dye require to be treated to make it commercially useful? How much useful dye is obtained from a given quantity of the coal-tar? What is it going to cost to extract it? What sort of commercial plant is most suitable? How are the various stages in the extraction to be arranged in the factory? What other materials, not immediately available will be needed? How reliable is the supply? What will the raw materials cost? Are there any other processes that might be handled with advantage at the same time? Are there any by-products, and what is to be done with them? There are many questions which call for careful study and experiment with model plant. At this stage, these questions cannot be answered either by the pure scientist or by the manufacturer. They require technical skill and an understanding of full-scale factory conditions, as well as of scientific experimentation.

An institution for the study of such problems I call an industrial laboratory. It is an essential

development, and an industrial system that does not deliberately provide for it can never hope to be efficient. The stream of pure science will pass it by, and the system will become obsolete. It is not enough to have one or two men with doubtful scientific qualifications, under-paid and over-worked, to handle the transference. The link has to be a strong one, or subsidiary industries will not develop from the main stem as they must do if the changing needs of the community are to be supplied.

Every industrialist, every manufacturer, every businessman who has entrusted to himself the task of carrying on industrial development, can now ask himself whether during times of peace and plenty he took serious thought of how scientific knowledge was to be utilised in his own manufacturing processes. Has he ever considered what experimental processes would have to be devised and tested in order that the natural resources of the country could be explored and used to the fullest extent? By natural resources, I refer not only to material and plant, but to scientific knowledge.

One does not have to wait for an answer to these questions. The answer is "No". If politicians and captains of industry, in whose hands the security of millions of our workers rest, had been alive to these problems, if they had been able to see production and consumption as a scientific whole, the disastrous gap between pure science and practical

manufacturing processes might long ago have been bridged. New ideas not merely make existing industries more efficient, but they create new industries—and that is infinitely more important.

It is worthwhile considering some of the reasons why there are so few developments of the kind I have indicated. It may mean that our captains of industry have not been alive to the importance of scientific research and to the necessity of utilising it as soon as it becomes available and arranging for its transference to industry. Again it may mean that our industries have been organised on too small a scale to afford the expense of research laboratories. If this last reason be true, then we must conclude that the individual existence in their present form of these small concerns is a serious drag on industrial progress. Is it possible for small-scale undertakings to envisage the larger issues that are vital to the community as a whole? Can they afford to take a long view? The answers to these questions should be sought by close scrutiny of the present organisation of industry and the ends which it is presumed to serve. Somewhere in between the scientific man and the machine, there is a gap which tends to render futile scientific ability and mechanical skill. It is the existence of that gap which I have endeavoured to reveal.

As civilisation becomes more mechanised and scientific, and as communal life comes to rely

more closely on the steady functioning of scientific processes, it is essential that educational methods should develop on parallel lines. Just as old machinery becomes obsolete and is scrapped, so false traditions and baseless superstitions must be discarded and eliminated from the social heritage. It is by education that we usually try to teach the difficult task of living together. If education is to fulfil its task, it will require to be permeated with the scientific spirit, it will require to eliminate from its teachings all superstitions and all beliefs that cannot stand critical examination. Education must be built upon a scientific basis. I am not now discussing technical education. My plea is for something fundamentally cultural.

In a thousand ways, science has already been called in to the help of education—books, pictures, films, gramophones, wireless, are all aids to learning. But these things are the machinery of science; the spirit of science has yet to be liberated for educational service and instilled into social relations. It is a problem that calls for the enterprise and initiative of our generation of teachers and thinkers. By striving to permeate social life with the spirit of critical foresight, by seeking to guide conduct with accurate knowledge, science may yet carve out a new future for mankind.

THE END.